



DEPARTMENT OF THE ARMY
UNITED STATES MILITARY ACADEMY
West Point, New York 10996

**REPLY TO
ATTENTION OF
MADN-CLS**

04 September 2024

MEMORANDUM THRU COL F. John Burpo, Department Head, Department of
Chemistry and Life Science, United States Military Academy, West Point, NY 10996

FOR Dean of the Academic Board, United States Military Academy, West Point, NY
10996

SUBJECT: 2024 Executive Summary of Chemical Engineering (CEN1) Program
Assessment

1. This memorandum is an executive summary, per *DPOM 5-07 Assessing and Improving Student Learning in the Academic Program*, outlining the changes in the Chemical Engineering Program's assessment and assessment process, as well as curriculum changes, that have occurred since the last executive summary in September 2023, in response to program assessment.

a. After being approved as permanent USMA Redbook offerings, course materials for CH300, Biomedical Engineering and CH350, Bioprocess Engineering were reviewed by the USMA ABET Committee in AY24-1 for Engineering Topics (ET) credit hours. The ABET Committee recommend for CH350 to be updated as 1.0 credits of Basic Science (BS) and 2.0 credit of ET. It was also determined that CH300 be updated to 2.0 credits of BS and 1.0 credit of ET. The current efforts in AY25-1 are to propose a new 5-course Bioengineering Minor comprised with CH300 and CH350 to compliment other courses in the chemical engineering (CEN1), life science (LSC1), chemistry (CHM1), mechanical engineering (MEN2), environmental engineering (EVE1), kinesiology (KIN1), and electrical engineering (EEN1) majors that build on biomedical/biochemical concepts, as well as additional background useful for the upper level major courses. The minor proposal is being staffed by all USMA departments for feedback to develop a resolution matrix to be defended and reviewed by the USMA Curriculum Committee on 26 September 2024.

(1) After completing a curricular change in AY23 to move the Writing in the Major (WiM) requirement for cadets majoring in CEN1 and Chemical Engineering Studies (CES1) requirement to CH459 Chemical Engineering Laboratory course, a Signature Writing Event (SWE) assignment as an Executive Summary on the Distillation Unit Operation was executed for the class of 2024 in AY24-1 in CH459.

(2) The standard 8TAP that reflects the curriculum is shown in the attached document "Encl 1 - exsum_CEN1_2024_08 - 8TAP".

b. Student Learning Outcomes (SLO) or Student Outcomes (SO) Assessment. The Chemical Engineering Major (CEN1) contains program elements recommended by ABET as Student Outcome (SO) 1-7, +8 (program criterion as SO8) which are for this executive summary are synonymous to SLOs 1-7, +8 as shown in the “Encl 2 - exsum_CEN1_2024_08 - Program Student Outcomes”.

(1) For AY24, the Chemical Engineering Program continued to assess performance against the SOs required by ABET and implemented in AY19. The updated assessment process was fully described in the 2019 Executive Summary of the CEN1 Program and more fully described in the 2020 ABET Self-Study.

(2) The SO assessment process requires analysis of our assessment data pack, followed by discussions among faculty members, advisory board members, and students. The assessment data pack for AY24 is included in the attached document “Encl 3 - exsum_CEN1_2024 Assessment Data 2024_08.” However, the assessment process is not complete until our advisory board meets after Spring Break in AY25-2 and will be submitted upon completion of our process. A completed assessment for AY23 with advisory board feedback is included as a reference in the attached document “Encl 4 - exsum_CEN1_2023 Assessment Data after Advisory Board_2024_08”. The advisory board table on page 24 was updated with the new survey data. Of note, the performance of cadets on the Fundamentals of Engineering Exam (FEE) during AY24 was higher than AY23 on the first attempt and overall. The first attempt passing rate was 73.6%. One more chemical engineer passed the FEE on the second attempt for an overall 78.9% pass rate (15/19 Cadets Passed the FEE Overall) for Class of 2024 which is above this year’s national chemical engineering average pass rate of 73.2%.. While we strive for a 100% pass rate, we are proud to have exceeded the national average in years prior that the program has been offered. As shown in “Encl 5 - exsum_CEN1_2024-08-FEE Results AY24”, the average FEE passing rate has been higher than the national average for nine years in a row and 12 out of the last 13 years.

(3) FE exam data for Student Outcome 8 (SO8) is shown in the attached document “Encl 5 – exsum_CEN1_2024-08-FEE Results AY24” (See page 2 and 3 of Encl 5 for FEE data comparison to previous years). The data shows an improvement this year in 14 of the 18 topics on the FEE compared to last years performance. Additionally, cadets aggregated scores on Engineering Sciences, Materials Science, Solids Handling, and Economics were greater than the national average. The cadets’ performance on Mathematics, Heat Transfer, Mass Transfer & Separations, Process Design, Safety Health & Environment, and Ethics & Professional Practice was almost one standard deviation below the national average. Moreover, the overall performance in Material & Energy Balances, Process Design, and Probability & Statistics, are trending upward compared to last year’s performance. Overall, the cadets performed closest to the national average in Thermodynamics and has been near the national average for the last two years. Process control is near the national average but the score increased drastically compared to last year. Performance in these two topics are important because they are an example of how the program improves cadet performance on our student outcomes. In the ABET assessment process, we must

demonstrate that we are assessing performance and that we are responding to performance indicators. We must also demonstrate that the department is willing to commit resources to the improvement process. These two focus areas are center to the overall ABET process. The addition of these two courses (CH365 and CH367) demonstrates our effort to achieve this. We also have documentary evidence to show exactly why we made the changes. The addition of CH365 in AY13 and CH367, Process Controls in AY19 demonstrates our assessment-based effort at program improvement.

(4) The remaining topics on the FE exam were generally within historical variations and/or standard deviations.

(5) During AY24 the program continued to utilize program-developed 1/0 rubrics to assist course directors in more precisely defining embedded indicators. Of significant note, all course directors completed this part of the program assessment correctly and on time. This saved considerable time in the preparation of the assessment data in Enclosure 3 - 2024 Assessment Data.

(6) We acknowledge lower than average scores shown in Enclosure 2 – 2024 Assessment Data for CH400, Chemical Engineering Professional Practice on Student Outcome 1 (SO1) and Student Outcome 4 (SO4). This course presents challenging homework and quiz problems to provide adequate FEE preparation for the first-class cadets (Firsties). The program has a high level of expectation in CH400 and therefore the scores of the graded events are slightly lower on average than our other chemical engineering courses. CH400 prepares Firsties for professional practice as chemical engineers, and combines the fundamental chemical engineering curriculum into a comprehensive course. We also acknowledge that the cadet surveys have also rated CH400 lower than other courses due to the difficulty of graded events, which we see as a positive result.

(7) The chemical engineering program addresses ethics and process safety separately for the purposes of assessment through Student Outcome 4 (SO4) and our Program Criterion (SO8), respectively. Standards and ethics are discussed throughout the curriculum in the core courses, CH400 and the capstone course, CH402 Chemical Engineering Process Design. The program addresses the hazards associated with chemical processes, and process safety education in the curriculum through CH459 and CH402. As shown in Enclosure 5 – FEE Results AY23, the cadets have outperformed the national average on the process safety aspects of the FEE as exemplified by the cadet's performance above the national average in Ethics & Professional Practice and very close to the national average on Safety, Health & Environment.

(8) The program continues to support the Academic Program Goals and the statements of What Graduates Can Do. The mapping between our SOs and the APG/WGCD statements is found in "Encl 6 – exsum_CEN1_2023-08 APG-WGCD

Mapping”. Numerical scores are included in the attachment. The scores are based on grades on embedded indicators on a 0-5 scale. Thus a 4 is 80%. In all cases, scores are above 4 and many are above 4.5. The program averages from Enclosure 3 – Assessment Data for all SOs (1-7) are mapped to indicators for specific APGs supporting their respective WGCDs. Therefore, the program embedded indicator scores were applied for each respective SO as shown in Encl 3.

c. Other than the stated change to the assessment process to reflect ABET accreditation criteria, there are no planned changes to the Chemical Engineering program’s assessment process.

d. Assessment schedule. The program assessment process is currently in progress. The process is initiated during the summer of 2024 when the data assessment packet is distributed to faculty for analysis. Program assessment for AY24 will be complete by 1 July 2025 (following our next advisory board meeting, at which time the board will evaluate the program data of AY2024) and Enclosure 3 will be update at that time. The planned Advisory Board meeting for AY24 will occur in late April or early May 2025.

e. Our last ABET record year was AY19-20 with a remote onsite visit took place 14-19 November 2020. Overall, the program passed with positive feedback on all aspects. The program strength was reported to be a focus process design and safety portion of the program and with the use of process simulators in the curriculum. We are actively preparing for the next ABET record year in AY26 with a focus on our current program assessment and the creation of two new elective courses in bioengineering for CEN1 majors.

f. We have examined the complimentary support courses and they provide a foundational math and applied science framework. As shown in the end of semester survey response results from cadets, EE301, Fundamentals of Electrical Engineering had the lowest scores student survey feedback for SOs 1, 2, 6, and 7. EE301 provides the basis for understanding of electronic circuits to aid chemical engineering process control modeling. As a program, we met with Electrical Engineering Program leadership and EE301 course leadership in AY23 to discuss ways integrate more applicable examples into classes to better connect the course content to chemical engineering processes. Conversations continue between Chemical Engineering and Electrical Engineering faculty on ways to incorporate chemical engineering problems within course content. Moreover, MA364/365, Engineering Mathematics had the lowest scores for SOs 3, 4, and 5. MA364/365 provide the basis and background of the advanced math skills required to master the chemical engineering curriculum moving forward. Program leadership is coordinating with MA364/365 leadership to discuss the identity of MA365 and its role in training chemical engineering cadets. PH206/256 Physics II provides a deeper understanding of electricity and magnetism with mathematics and underlying science that is part of CEN1. Overall, the complimentary courses serve as a strong fundamental basis for courses in the major.

2. Point of contact for this action is the AY24 Chemical Engineering Program Director, Dr. Enoch A. Nagelli, at x3904.

6 Enclosures

1. Approved CEN1 8TAP
2. Program Student Outcomes
3. AY24 Assessment Process and Data
4. AY23 Assessment Process and Data
5. FEE Topical Outcomes Evaluation
6. APG-WGCD Mapping

ENOCH A. NAGELLI PH.D.

Associate Professor

Chemical Engineering Program Director (AY24)

**Enclosure 3 to 2024 Executive Summary of Chemical Engineering Program
Assessment: Assessment Process and Data**

This document is a separate file entitled "Encl 3 - exsum_CEN1_2024 Assessment Data 2024_08"

This file was published to the program on 31 July 2024. An updated file containing Faculty, Advisory Board, and Program Director survey data and input will be published o/a 1 June 2025.

**Enclosure 1 to 2024 Executive Summary of Chemical Engineering Program Assessment: Approved CEN1 8TAP
CEN1 - Class of 2024**

4th Class Year Fall Term	Spring Term	3rd Class Year Fall Term	Spring Term	2nd Class Year Fall Term	Spring Term	1st Class Year Fall Term	Spring Term
<i>E</i> MA103 4.0	<i>E</i> MA104 4.5	<i>E</i> MA205 4.5	<i>R</i> CH362 3.5	<i>R</i> CH363 3.5	<i>R</i> CH364 3.5	<i>D,R</i> CH459 3.5	CH402 3.0
EV203/ CH101 4.0	<i>R</i> CH101/ PH205 4.0	<i>R</i> PH205/ PH206 4.0	<i>R/</i> EV203/ PH206 4.0	<i>R</i> EE301 3.5	CH367 3.0	CH365 3.0	CH400 1.5
EN101 3.0	EN102 3.0	<i>R</i> CH102 4	MA364/5 3.0	<i>R</i> CH383 3.5	ME362 3.5	<i>R</i> CH485 3.5	Engr Elective 3.0
IT105 3.0	PL100 3.0	<i>E</i> DFL1 4.0	PY201 3.0	ME301 3.5	MC300 3.0	Engr Elective 3.0	LW403 3.5
HI105 3.0	HI108 3.0	<i>R</i> SS201 3.5	<i>E</i> DFL2 4.0	PL300 3.0	SS307 3.5	Engr Elective 3.0	<i>R</i> HI302 3.0
			<i>R</i> SS202 3.5	MA206 3.0			MX400 3.0

D = Double blocked course

R = RSTU lab course

E = Meet every day for 55 minutes

	Course should not be moved from that year or term
	Course may be scheduled in the fall or spring of that academic year
	Complementary Support Courses
	Core Engineering Sequence (not applicable) Course
	3 Science Depth
	Course 9 STEM Depth
	other electives - most popular electives are templated

**Enclosure 2 to 2024 Executive Summary of Chemical Engineering Program Assessment:
Approved CEN1 ABET Student Outcomes and Program Criterion
CEN1 - Class of 2024**

The Chemical Engineering Major contains all the program elements recommended by ABET. To be consistent with our program assessment for the ABET accreditation process, “**Student Outcomes (SOs) (ABET 1-7, +8 as Program Criterion)**” below are equivalent to the “**Student Learning Outcomes (SLOs)**” per *DPOM 5-07 Assessing and Improving Student Learning in the Academic Program*. Graduates who complete a Chemical Engineering Major will be able to do the following:

- **Student Outcome 1 (SO1):** *Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.*
- **Student Outcome 2 (SO2):** *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.*
- **Student Outcome 3 (SO3):** Communicate effectively with a range of audiences.
- **Student Outcome 4 (SO4):** 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.
- **Student Outcome 5 (SO5):** Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
- **Student Outcome 6 (SO6):** Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- **Student Outcome 7 (SO7):** Acquire and apply new knowledge as needed, using appropriate learning strategies.
- **Program Criterion (Student Outcome 8 - SO8):** The Chemical Engineering Program provides the graduate with a through grounding and working knowledge of:
 - a. Chemistry,
 - b. Material and energy balances,
 - c. Safety and environmental factors,
 - d. Thermodynamics of physical and chemical equilibria,
 - e. Heat, mass, and momentum transfer,
 - f. Chemical reaction engineering,
 - g. Continuous and staged separation operations,
 - h. Process dynamics and control,
 - i. Modern experimental and computing techniques, and
 - j. Process design.

PROGRAM ASSESSMENT DATA AY2024

UNITED STATES MILITARY ACADEMY
DEPARTMENT OF CHEMISTRY AND LIFE SCIENCE
CHEMICAL ENGINEERING PROGRAM
July 31, 2024

<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>19</u>

Evaluations

Faculty.....	<u>21</u>
Advisory Board.....	<u>22</u>
Program Director	<u>23</u>

Note: When complete, the results will be summarized in the “Evaluations” section. The “Evaluations” section is a working draft at this time. Faculty data will be added when complete in August 2024. Advisory board assessment is not available until spring 2025 after the next advisory board meeting

Working Draft – Last updated on 31 July 2024

- Transcript analysis added 28 May 2024.
- End-of-Semester Student Surveys added 28 May 2024.
- Chemical & Mech. Eng. Coursework Embedded Indicators added 31 July 2024
- Course grades in CH402 and CH459 added on 28 May 2024.
- FEE data added 25 July 2024.
- Advisory Board data added ... (spring 2025, when available).
- Lifelong learning skills rubric for Outcome 7 added on 29 May 2024.
- Program exit survey added 28 May 2024.
- Contemporary issues added on 28 May 2024.
- Teamwork Skills Rubric (Peers) from CH459 added on
- Faculty Survey data was added on ... (when complete).

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

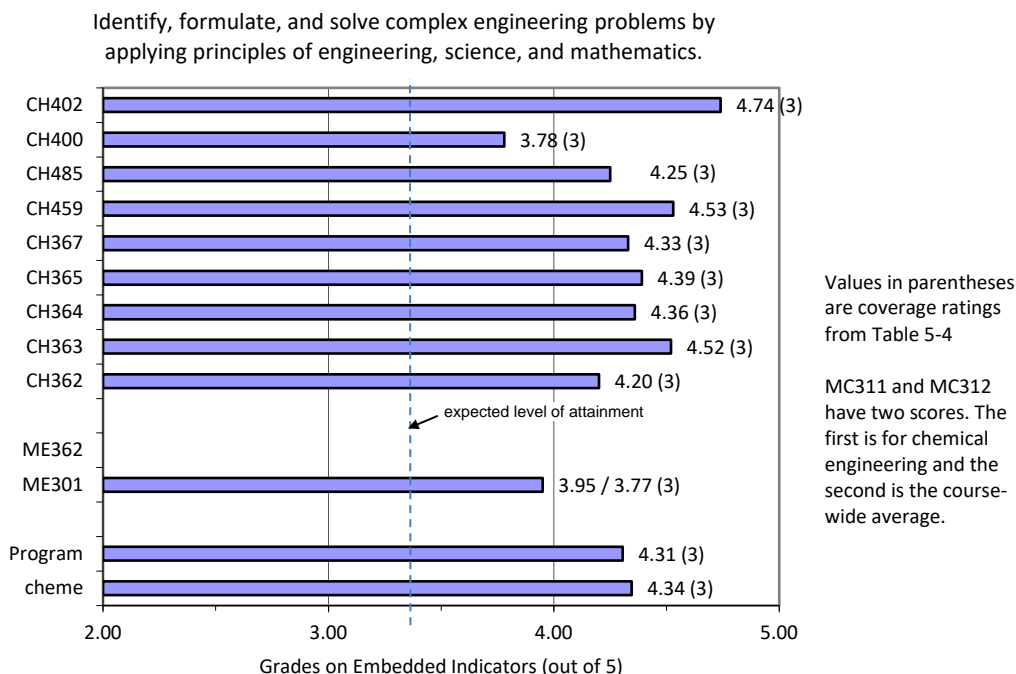


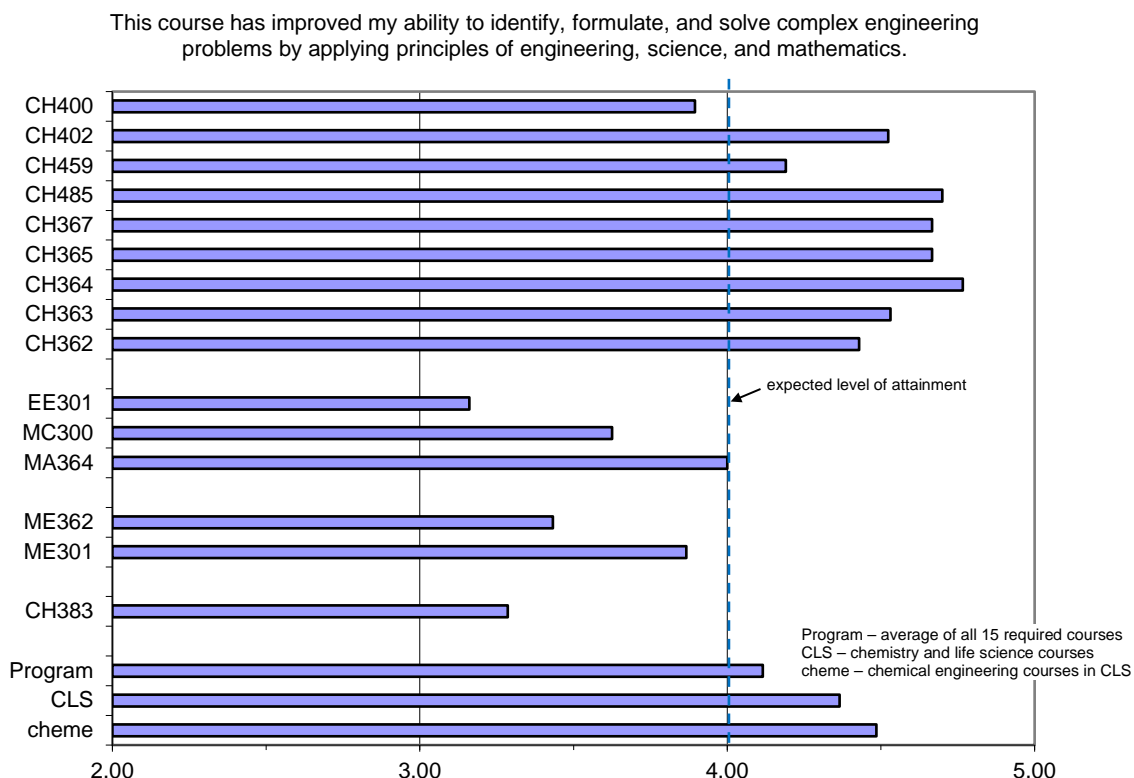
Figure 1-1. Coursework Embedded Indicator results for Student Outcome 1.

2. Fundamentals of Engineering Examination (FEE). According to the 2024 report from NCEES, 14 out of 19 cadets in the Class of 2024 took and passed the FEE. After one successful re-take, our program is at 15 out of 19, or 78.9%. The national average passing in 2024 was 73.2%, and this is our expected level of attainment. In the previous five years, the pass rates were 76.9% in 2023, 91.3% in 2022, 85.0% in 2021, 77.8% in 2020, and 87.5% in 2019. Our running average over those previous five years is $83.7\% \pm 6.2\%$ (versus $73.3\% \pm 2.2\%$ for the national average).

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

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.” 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 21 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 19/21 replying that they strongly agreed (score = 5/5) and two cadets replying that they agreed (score = 4/5). This equates to a mean score of $4.91/5.00 \pm 0.30$ for the 21 cadets participating in the survey. 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

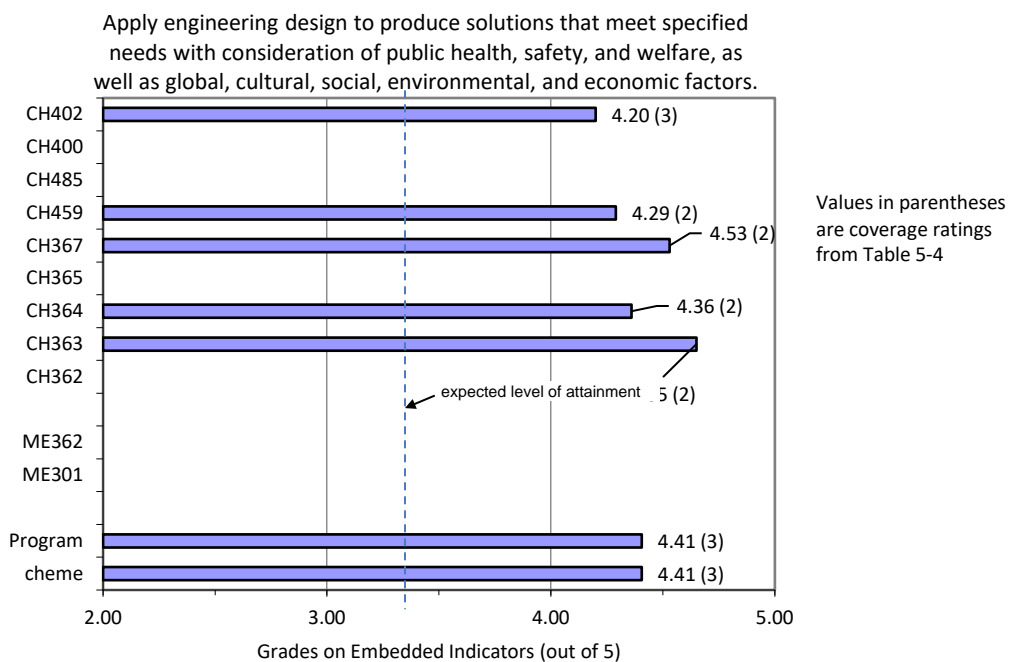


Figure 2-1. Coursework Embedded Indicator results for Student Outcome 2.

2. End of Semester Student Surveys

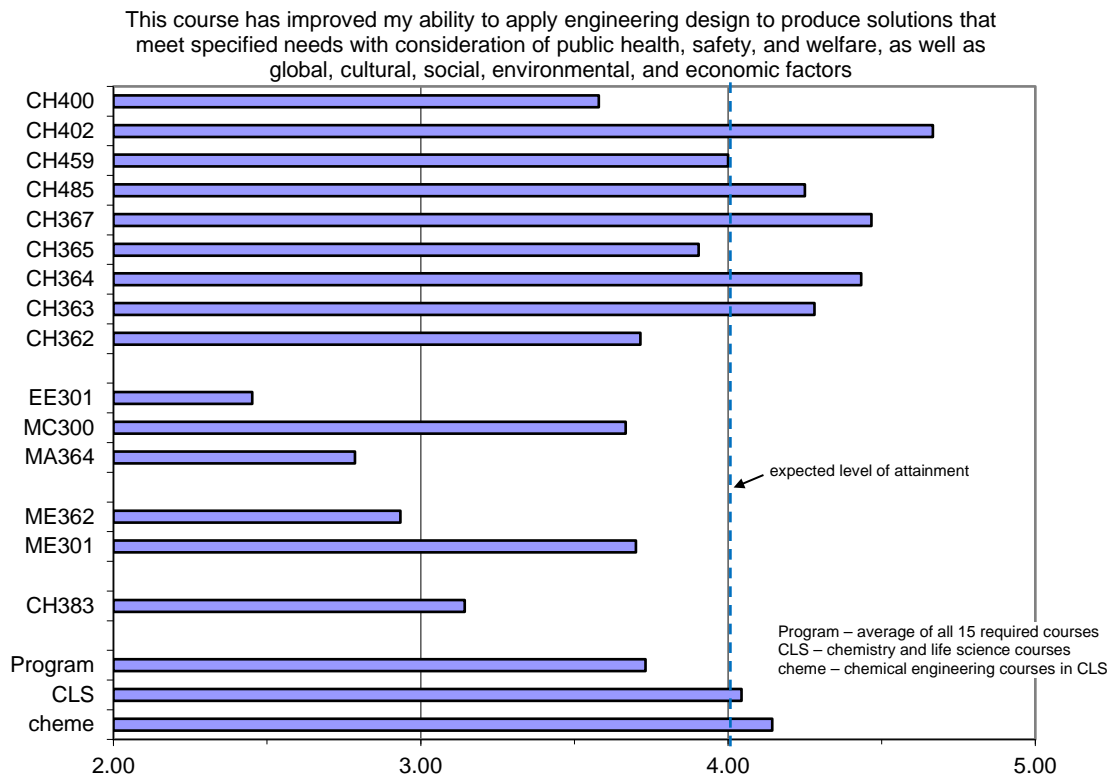


Figure 2-2. End-of-Semester Student Survey responses for Student Outcome 2.

- The average course grade in CH402 Chemical Engineering Process Design was 3.65 ± 0.46 ($n=19$) in AY24, compared to 3.44 ± 0.55 ($n=13$) in AY23, 3.33 ± 0.50 ($n=23$) in AY22, 3.46 ± 0.68 ($n=20$) in AY21, 3.26 ± 0.70 ($n=29$) in AY20, and 3.27 ± 0.92 ($n=21$) in AY19. The 5-year running average for the previous five years is 3.35, and this is our expected level of attainment. This year's score was *above* the 5-year running average.
- 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." 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 20 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 12/21 replying that they strongly agreed (score = 5/5), 8/21 replying that they agreed (score = 4/5), and 1/21 that they were neutral (score = 3/5). This equates to a mean score of $4.52/5.00 \pm 0.60$ for the 21 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

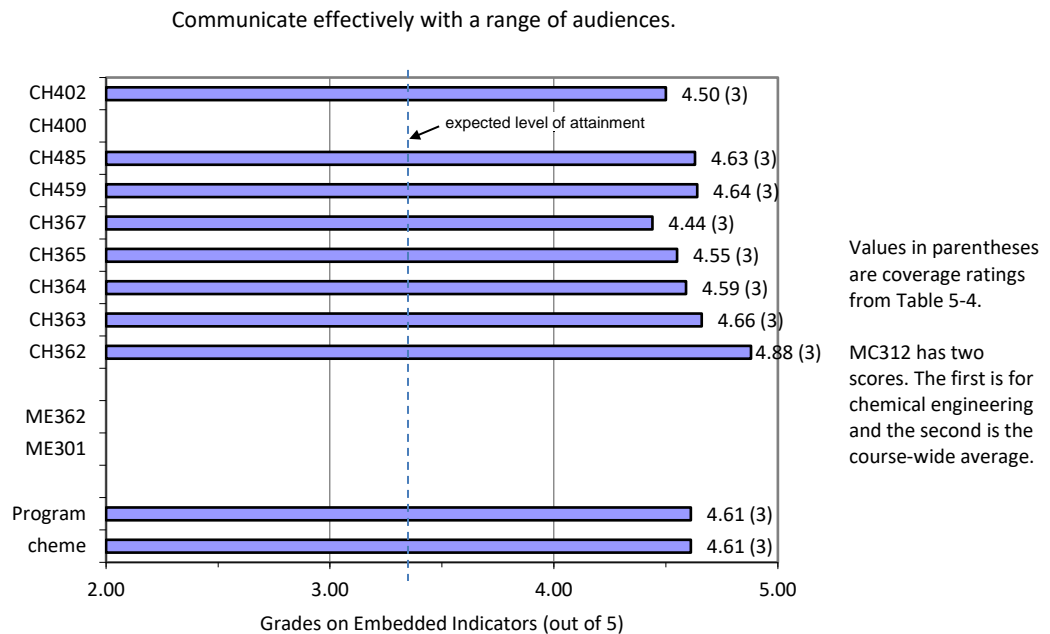


Figure 3-1. Coursework Embedded Indicator results for Student Outcome 3.

2. End of Semester Student Surveys

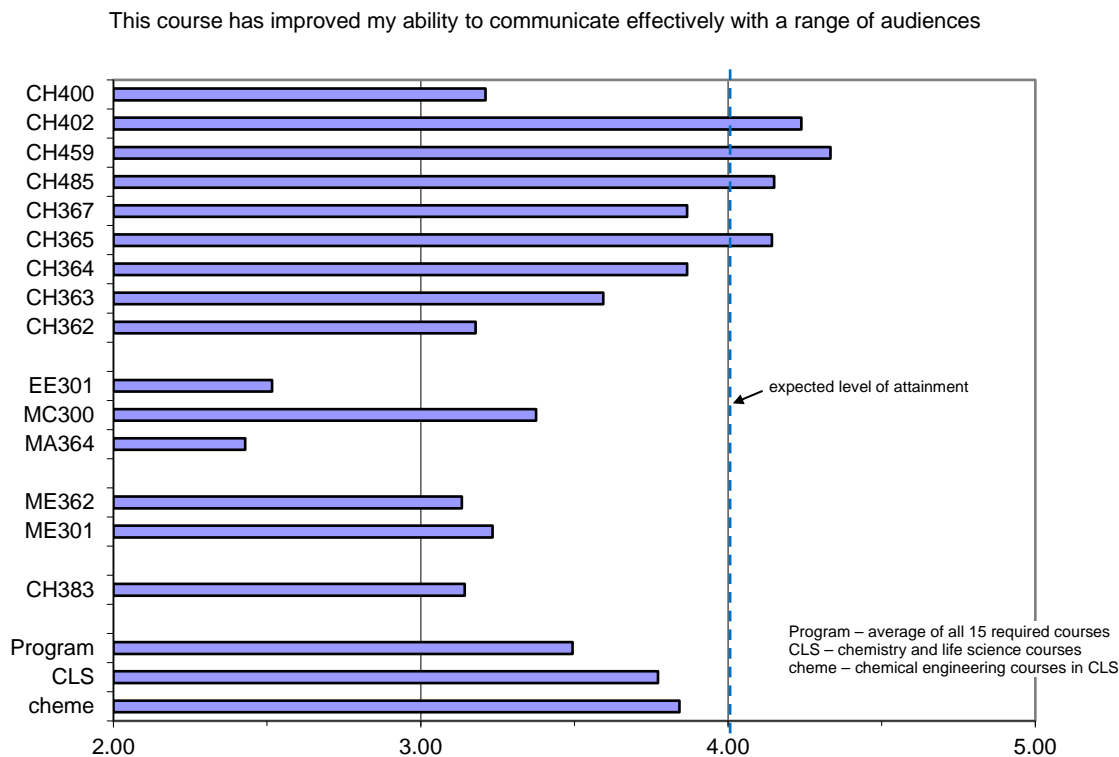


Figure 3-2. End-of-Semester Student Survey responses for Student Outcome 3.

3. The average course grade in CH459 Chemical Engineering Laboratory was 3.70 ± 0.46 ($n=19$) in AY24, compared to 3.41 ± 0.43 ($n=13$) in AY23, 3.80 ± 0.42 ($n=23$) in AY22, 3.67 ± 0.53 ($n=18$) in AY21, 3.53 ± 0.48 ($n=29$) in AY20, and 3.52 ± 0.44 ($n=19$) in AY19. The 5-year running average is 3.59, 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 they agree with the statement "The program has prepared me to communicate effectively with a range of audiences." 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 21 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 10/21 replying that they strongly agreed (score = 5/5), and 11/21 replying that they agreed (score = 4/5). This equates to a mean score of $4.48/5.00 \pm 0.51$ for the 21 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

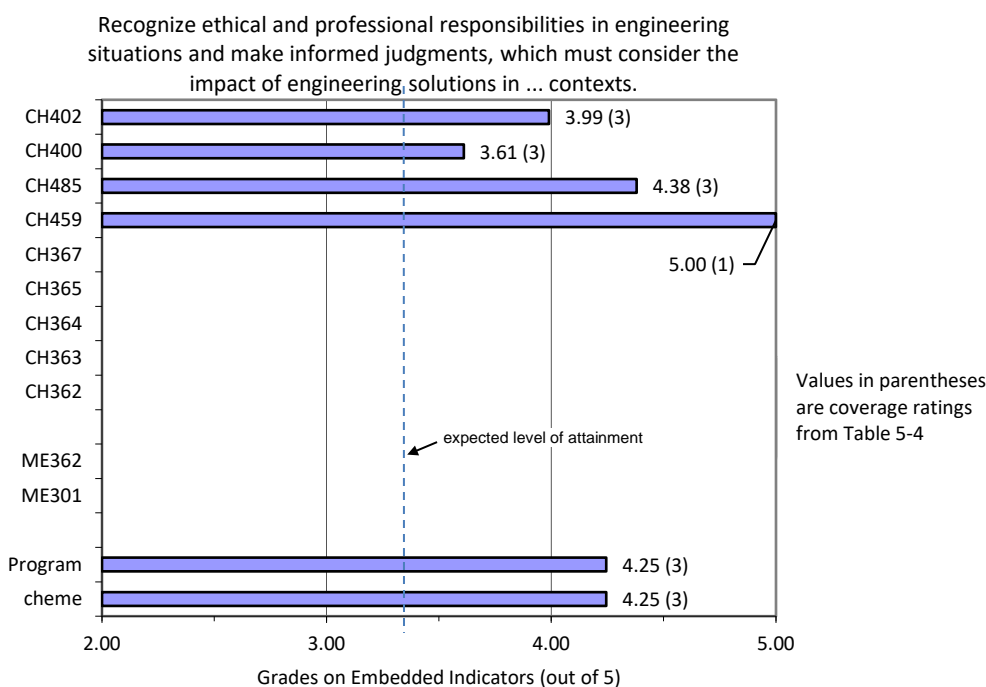


Figure 4-1. Coursework Embedded Indicator results for Student Outcome 4.

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	10.9	11.5 ± 4.4
Economics	4	4	10.6	10.2 ± 3.4

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

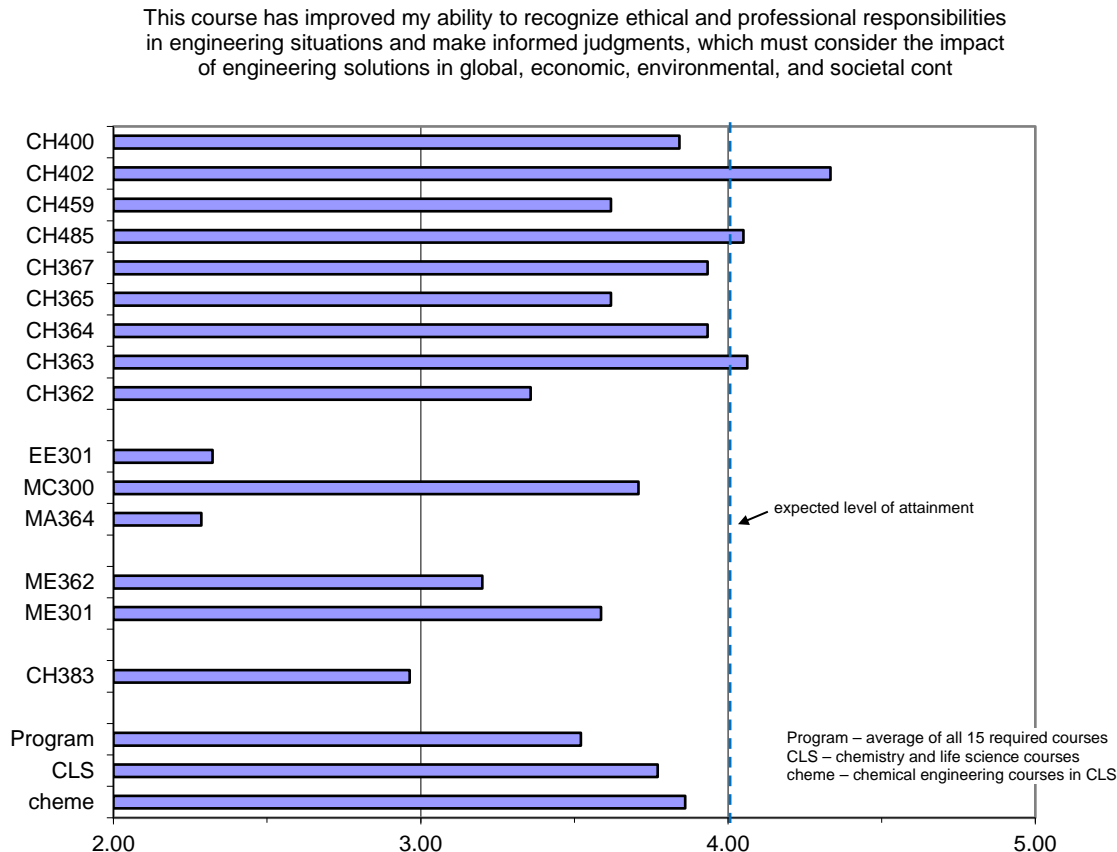


Figure 4-2. End-of-Semester Student Survey responses for Student Outcome 4.

4. Chemical Engineering Program Exit Survey. This survey is given to the Firsties at the end of their last semester. Cadets were asked to respond to 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.” 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 17 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 9/21 replying that they strongly agreed (score = 5/5), 8/21 replying that they agreed (score = 4/5), and 4/21 replying that they were neutral (score = 3/5). This equates to a mean score of $4.24/5.00 \pm 0.77$ for the 21 cadets. The expected level of attainment 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 23 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

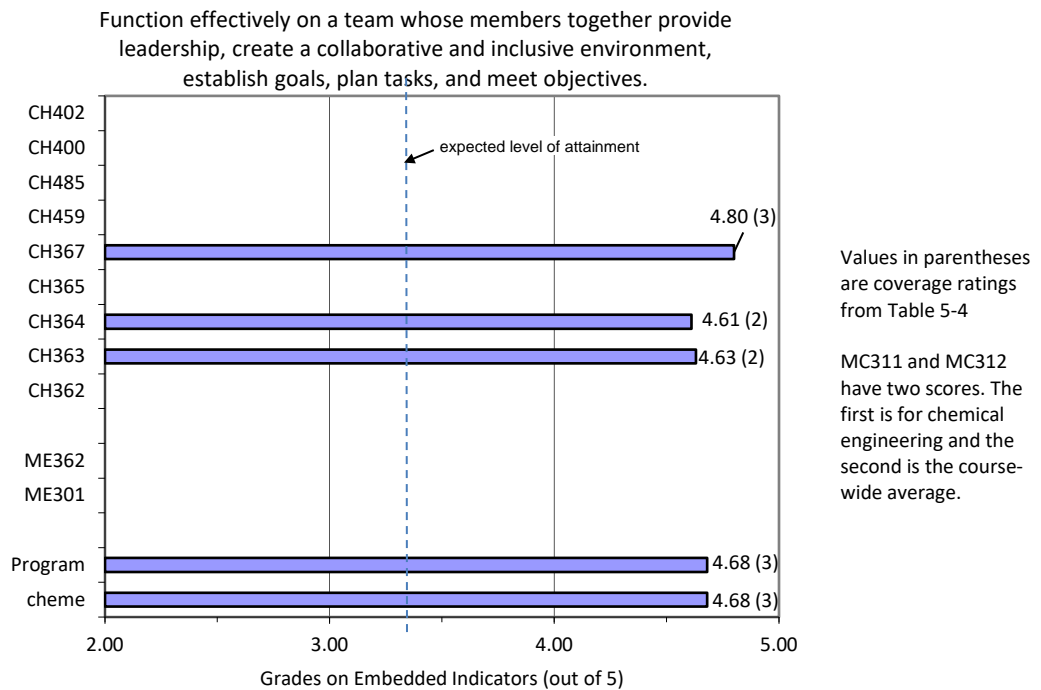


Figure 5-1. Coursework Embedded Indicator results for Student Outcome 5.

2. End of Semester Student Surveys

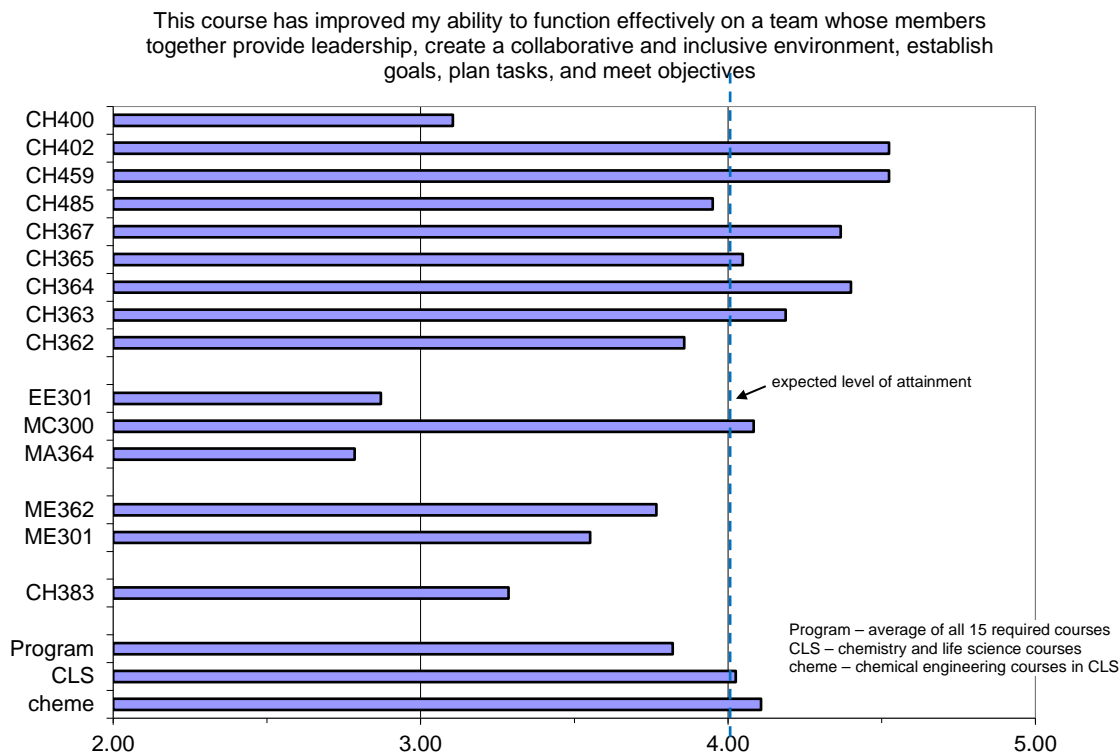


Figure 5-2. End-of-Semester Student Survey responses for Student Outcome 5.

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.” 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 21 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 17/21 replying that they strongly agreed (score = 5/5) and 4/21 replying that they agreed (score = 4/5). This equates to a mean score of $4.81/5.00 \pm 0.40$ for the 21 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.	4.7 ^a ±.17 ^c 4.6 ^b ±.21 ^c	
Communication				Effectively communicated important points.			Exceptional ability to explain important points. Very effectively communicated ideas for improvement.	4.6 ^a ±.12 ^c 4.6 ^b ±.32 ^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 ±.09 ^c 4.6 ^b ±.3 ^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 ±.09 ^c 4.5 ^b ±.19 ^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.				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: AY23, 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.	4.9 ^a ±.02 ^c 5.0 ^b ±0.0 ^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.	4.9 ^a ±.05 ^c 5.0 ^b ±0.0 ^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.	4.9 ^a ±.02 ^c 5.0 ^b ±0.0 ^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.	4.9 ^a ±.05 ^c 5.0 ^b ±0.0 ^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.				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: AY22, 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

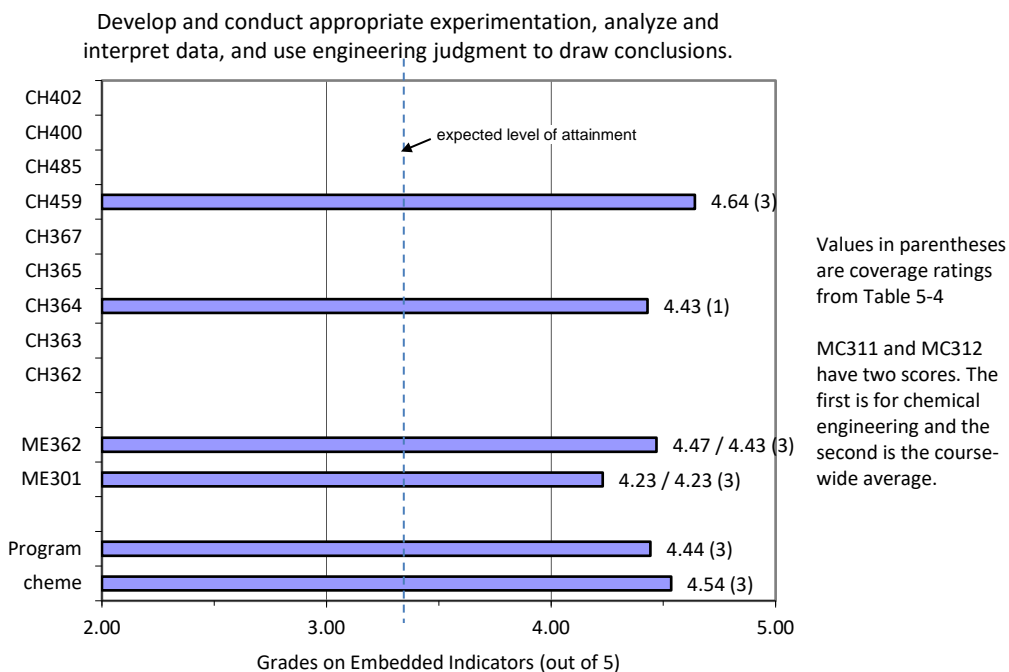


Figure 6-1. Coursework Embedded Indicator results for Student Outcome 6.

2. End of Semester Student Surveys

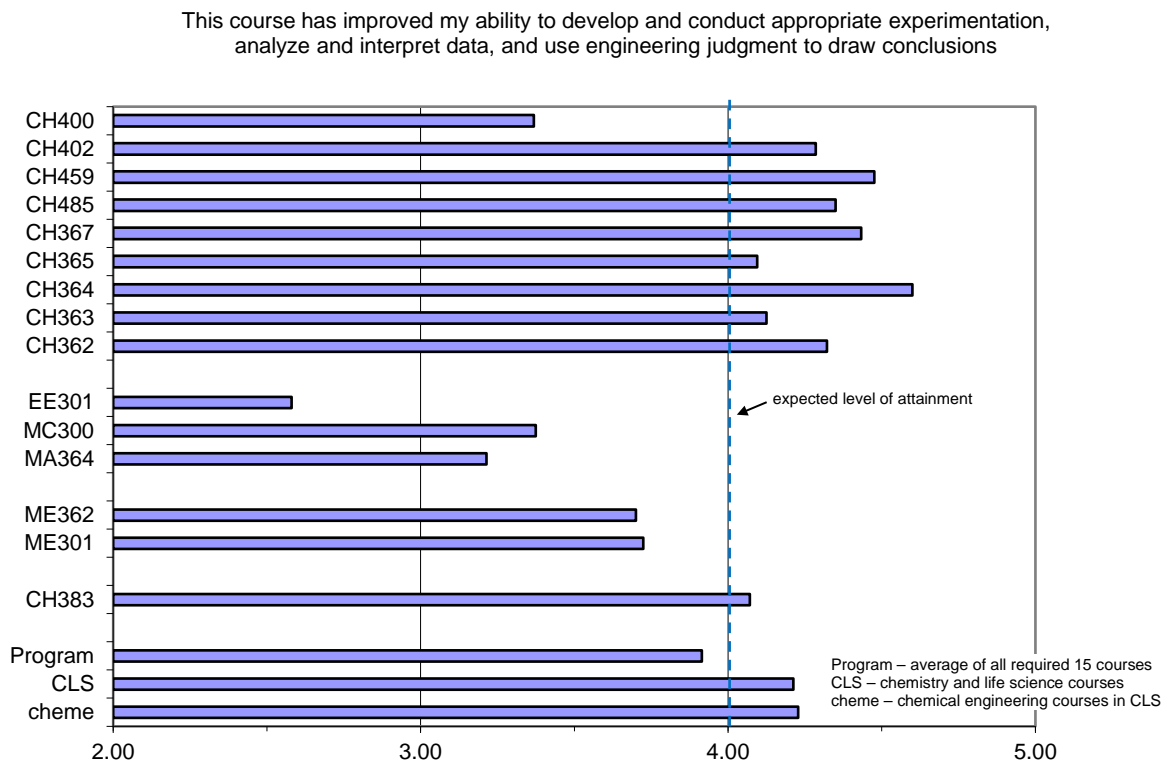


Figure 6-2. End-of-Semester Student Survey responses for Student Outcome 6.

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.” 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 20 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 17/21 replying that they strongly agreed (score = 5/5), 3/21 replying that they agreed (score = 4/5), and 1/21 replying that they were neutral (score = 3/5). This equates to a mean score of $4.76/5.00 \pm 0.54$ for the 21 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 3.70 ± 0.46 (n=19) in AY24, compared to 3.41 ± 0.43 (n=13) in AY23, 3.80 ± 0.42 (n=23) in AY22, 3.67 ± 0.53 (n=18) in AY21, 3.53 ± 0.48 (n=29) in AY20, and 3.52 ± 0.44 (n=19) in AY19. The 5-year running average is 3.59, and this is our expected level of attainment. This year’s score was above the 5-year running average.

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

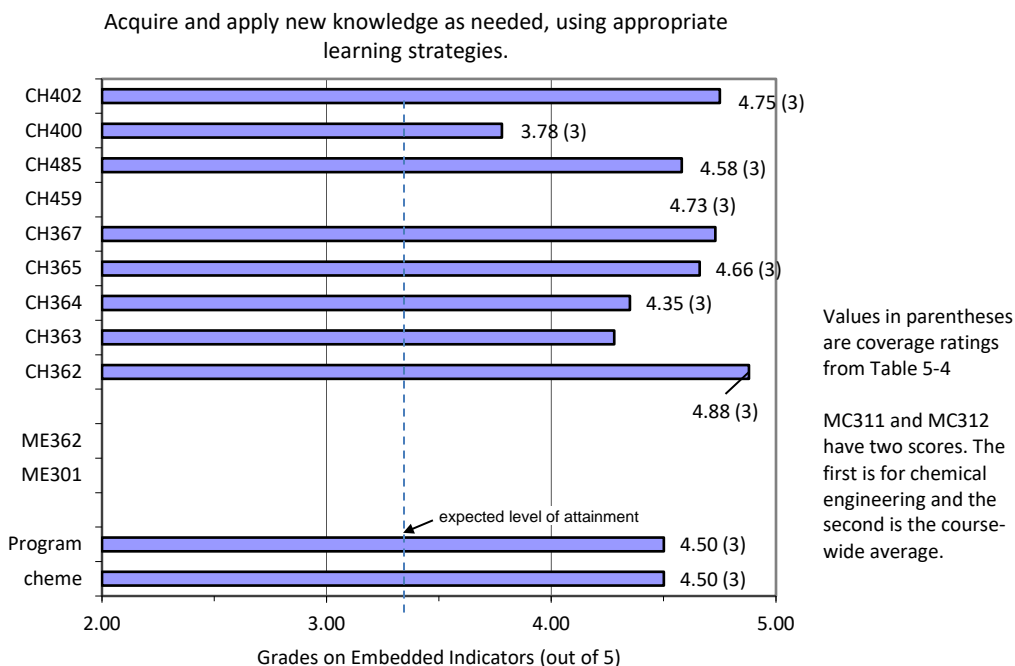


Figure 7-1. Coursework Embedded Indicator results for Student Outcome 7.

2. Percent of Eligible Cadets taking the Fundamentals of Engineering Examination (FEE). For the Class of 2024, 19 of 19 chemical engineering cadets (100% of eligible cadets) prepared for and took the FEE. For the Class of 2023, 13 of 13 chemical engineering cadets (100% of eligible cadets) prepared for and took the FEE. This compares to 100% in years 2018 and 2019, with 31% in 2020 (9 of 29), and 100% in 2021, 2022, and 2023. 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 participants in 2019 to 480 in 2020, which recovered somewhat to 668 in 2021, 600 in 2022, 521 in 2023, and 654 in 2024. **Note: The participation rate is EXCELLENT.**

3. End of Semester Student Surveys

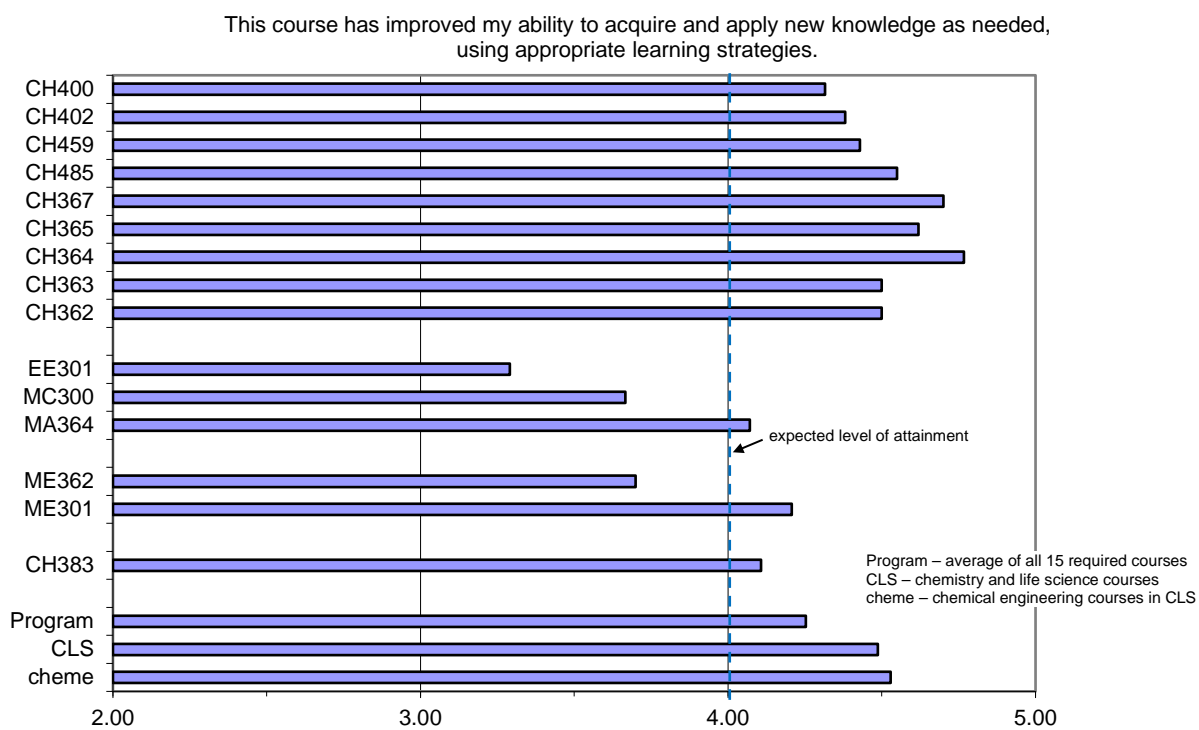


Figure 7-2. End-of-Semester Student Survey responses for Student Outcome 7.

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.” 21 out of 21 cadets completed the survey, including 1 studies cadet and one class of 2025 (turnback). Of these, 21 out of 21 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 14/21 replying that they strongly agreed (score = 5/5) and 7/14 replying that they agreed (score = 4/5). This equates to a mean score of $4.62/5.00 \pm 0.50$ for the 21 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), then revised at the end of the semester (assignment 2.1). 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: Summary, 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
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.
							5.0 ± 0.0
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.			Identifies specific skills learned in chemical engineering courses.
							4.6 ± 0.5
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.			Demonstrates an ability to effectively communicate in the resume format. Clear, concise content. Resume is interesting.
							4.8 ± 0.3
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Cadet scores were very good overall because most cadets read the assignment carefully, paid attention to the guidance, and wrote about ideas that met the rubric requirements. Final Grade: 4.7 ± 0.5 / 5.0					Assignment used for assessment: (e.g., resume draft 1.1 in CH365) resume draft 1.1 in CH365	

Instructor's Name: Biaglow				Cadet Assessed: Summary, 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
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.
							5.0 ± 0.0
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.			Identifies specific skills learned in chemical engineering courses.
							4.7 ± 0.5
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.			Demonstrates an ability to effectively communicate in the resume format. Clear, concise content. Resume is interesting.
							4.8 ± 0.3
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Scores increased slightly with respect to the first draft in row two (recognition). Scores were similar to last year. Instructor provided mentoring on inclusion of new content from current chemical engineering courses. Final Grade: 4.7 ± 0.5 / 5.0					Assignment used for assessment: (e.g., resume draft 1.1 in CH365) resume draft 2.1 in CH365	

There is normally improvement in scores in draft 2.1 as cadets incorporate instructor comments to improve and polish their documents. Version 2.1, though, requires articulation of new skills acquired during the semester. Scores can go down if cadets do not show new activities and skills learned during the current semester, and in some individual cases the scores did drop, and intellectual growth (row3) did increase. 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 (follows on page 18). 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 – impact of contemporary issues (ability to link contemporary issues to relevant chemical engineering concepts), 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, completed in two drafts. The draft and final submissions were graded against the rubric, with the total average score and average scores per outcome shown in the screenshots above. In AY24 (this year), the average for the draft was 4.0 ± 0.81 and the average on the final was 4.8 ± 0.4 , so cadets achieved a better average on the final than on the draft submission. Scores also showed some improvement year-to-year, compared to 3.8 ± 0.9 and 4.8 ± 0.5 in AY23 in the draft and final reports, respectively. We conclude that cadets achieved each of the graded rubric rows with proficiency, and instructor comments are included in the screenshots.

Instructor's Name: LTC Cowart				Cadet Assessed: All Cadets in CH485 (AY24-1)				
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 re-worded to support a thesis.		4.0 +/- 0.7	Uses multiple substantive examples or scholarly articles in an integrative fashion to support a thesis.	
Technical Competence Outcomes 8	Demonstrates poor or incomplete understanding of technical content.			Demonstrates some knowledge of the technical content, but explanation lacks adequate depth.		3.6 +/- 0.8	Demonstrates exceptional knowledge of technical content.	
Impact of Contemporary Issues Outcome 4	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.		3.9 +/- 0.7	Makes very clear connections between premise and chemical engineering concepts.	
Communication Outcome 3	Writing lacks organization or cohesion. Numerous grammatical errors or errors interfere with meaning. Thesis lacking or implied.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write an essay but lacks cohesion or completeness. Thesis not fully supported.		4.3 +/- 0.9	Demonstrates an ability to effectively communicate in the essay format. Fully supported, clear, concise thesis. Writing style was exceptionally clear and articulate.	
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Cadets met expectations on the draft writing assignment. Cadets demonstrated acquisition of new knowledge and generally wrote in an acceptable format. Technical content with respect to chemical engineering processes, including heat & mass transfer can be improved, as well as writing organization. Final Grade: 4.0 +/- 0.81					Assignment used for assessment: (e.g., draft 1 writing assignment 1 in CH485) CH485 Writing DRAFT		

Instructor's Name: LTC Cowart				Cadet Assessed: All Cadets in CH485 (AY24-1)				
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 re-worded to support a thesis.			Uses multiple substantive examples or scholarly articles in an integrative fashion to support a thesis.	4.8 +/- 0.4
Technical Competence Outcomes 8	Demonstrates poor or incomplete understanding of technical content.			Demonstrates some knowledge of the technical content, but explanation lacks adequate depth.			Demonstrates exceptional knowledge of technical content.	4.7 +/- 0.5
Impact of Contemporary Issues Outcome 4	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.	4.8 +/- 0.4
Communication Outcome 3	Writing lacks organization or cohesion. Numerous grammatical errors or errors interfere with meaning. Thesis lacking or implied.			Occasional grammar errors 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 +/- 0.4
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Significant improvement from the draft version of the contemporary issues essay. Technical improvement, inclusion of figures/drawings/schematics, coupled with extensive discussion of contemporary issues regarding the chosen topic resulted in interesting, thoughtful papers. Final Grade: 4.8 +/- 0.4					Assignment used for assessment: (e.g., draft 1 writing assignment 1 in CH485) CH485 Writing FINAL		

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	7	10.0	9.6±2.7
Material & Energy Balances	8.2	10	9.1	9.5±2.3
Safety, Health, & Environmental	8.3	5	9.6	10.1±3.3
Thermodynamics	8.4	8	9.2	9.4±2.2
Heat Transfer	8.5	8	8.6	9.8±2.5
Fluid Mechanics/Dynamics	8.5	8	9.2	9.4±2.4
Chemical Reaction Engineering	8.6	7	9.2	9.6±2.3
Mass Transfer & Separations	8.7	8	9.0	9.7±2.3
Process Control	8.8	4	10.0	10.2±3.4
Computational Tools	8.9	0	---	---
Economics	8.10	4	10.6	10.2±3.5
Process Design	8.10	7	9.2	9.8±2.5

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	2.53								
CH365	Chem. Eng. Thermo.			3.82						
CH362	Mass & Energy Balances		3.48							
CH363	Separation Processes						3.68			
CH364	Chem. Reaction Eng.					3.54				
CH459	Chem. Eng. Laboratory								3.70	
CH485	Heat and Mass Transfer				3.14					
CH400	Chemical Engineering Sem.									
CH402	Chem. Eng. Process Des.									3.65
MA366	Vector Calculus									
ME301	Thermodynamics			3.46						
ME362	Fluid Mechanics				3.32					
CE300	Fund. Eng. Mech. & Des.									
EE301	Intro. To Elec. Engineering									
CH367	Intr. Auto. Process Control							3.28		
Average Grade 2024		2.53	3.48	3.64	3.23	3.54	3.68	3.28	3.70	3.65
Average Grade 2023		2.64	3.17	3.35	3.21	3.38	3.59	3.51	3.41	3.44
Average Grade 2022		3.15	3.64	3.59	3.47	3.33	3.69	3.42	3.80	3.33
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
Previous 5-year Running Average (Expected level of attainment)		2.95	3.50	3.45	3.28	3.41	3.64	3.43	3.59	3.35
Standard Deviation 2024		0.76	0.48	0.58	0.52	0.47	0.48	0.67	0.47	0.46

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.	4.91 ± 0.30
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, environmental, and economic factors.	4.82 ± 0.40
3. Communicate effectively in the professional setting.	4.55 ± 0.52
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering decisions in society, the environment, and the global context.	4.91 ± 0.30
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and execute on those goals.	4.91 ± 0.30
6. Develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment to draw conclusions.	4.64 ± 0.50
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.82 ± 0.40
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and environmental factors, thermodynamics of physical and chemical equilibria, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.	4.91 ± 0.30
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

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

Engineering Student Outcomes		Advisory Board's Evaluation
On completion of the chemical engineering program, our graduates are able to:		
1. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as economic factors.		4.89 ± 0.33
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as economic factors.		
3. Communicate effectively with diverse audiences.		4.78 ± 0.44
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions on global, economic, environmental, and societal conditions.		4.89 ± 0.33
5. Function effectively on a team whose leadership rotates among its members; provide leadership, create a collaborative and inclusive team environment, establish goals, plan tasks, and execute on the plan.		4.89 ± 0.33
6. Develop and conduct appropriate experiments; analyze and interpret data, and use engineering judgment.		4.56 ± 0.73
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.		4.78 ± 0.44
8. Understand the chemical engineering curriculum, including chemistry, material and energy balances, safety and health, thermodynamics of physical and chemical equilibrium, mass, and momentum transfer, chemical reaction engineering, continuous and staged separation processes, process dynamics and control, modern experimental and computing techniques, and process design.		4.67 ± 0.50
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor		

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. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as economic factors.	5	
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as economic factors.	5	
3. Communicate effectively with a variety of audiences.	5	
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions on global, economic, environmental, and societal conditions.	5	
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive team environment, establish goals, plan tasks, and execute on those goals.	5	
6. Develop and conduct appropriate experiments, analyze and interpret data, and use engineering judgment.	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 health, thermodynamics of physical and chemical equilibrium, 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		

PROGRAM ASSESSMENT DATA AY2023

UNITED STATES MILITARY ACADEMY
DEPARTMENT OF CHEMISTRY AND LIFE SCIENCE
CHEMICAL ENGINEERING PROGRAM
April 15, 2024

<u>Student Outcome</u>	<u>Page</u>
1.....	1
2.....	3
3.....	5
4.....	7
5.....	9
6.....	12
7.....	14
8.....	21

<u>Evaluations</u>	
Faculty.....	23
Advisory Board.....	24
Program Director	25

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

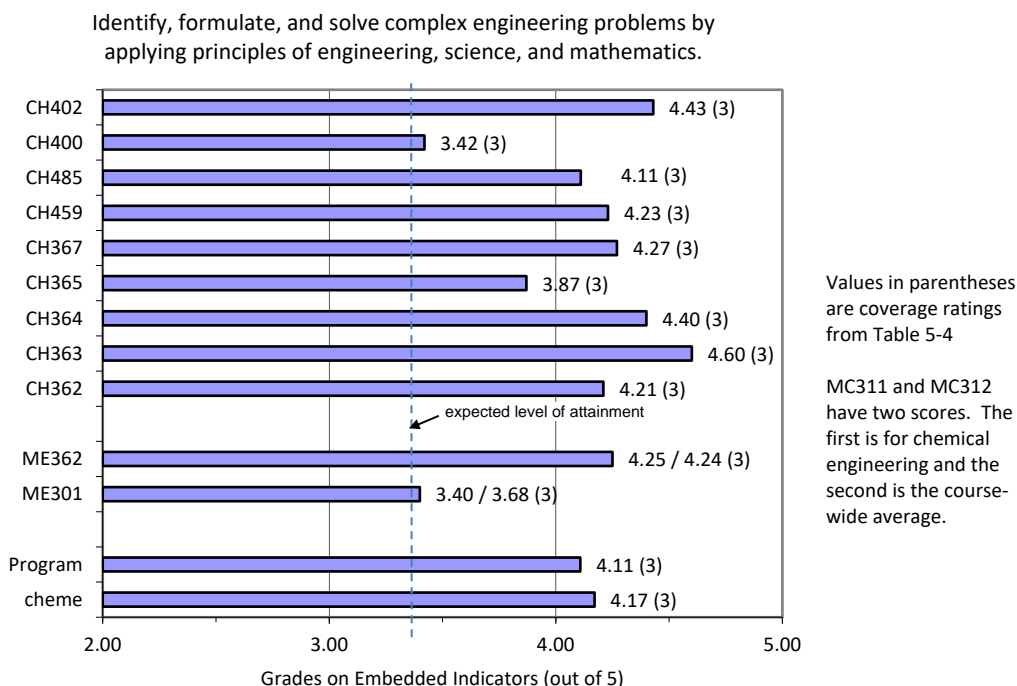


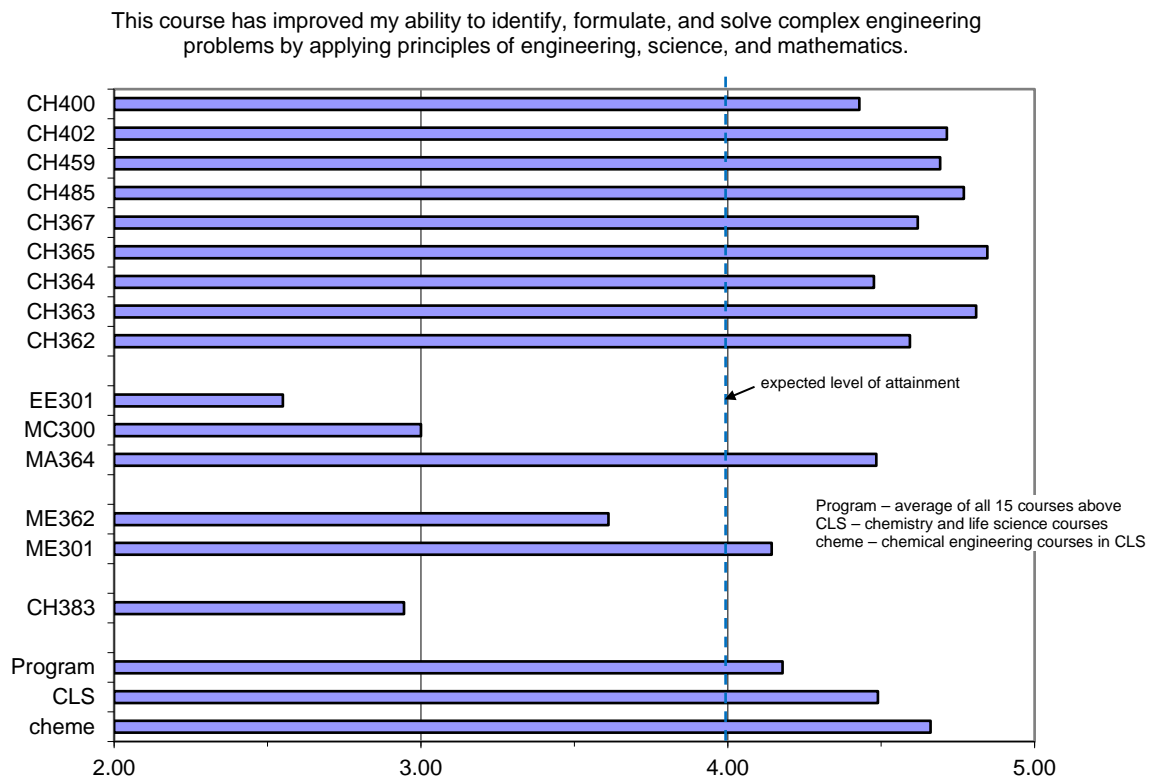
Figure 1-1. Coursework Embedded Indicator results for Student Outcome 1.

2. Fundamentals of Engineering Examination (FEE). According to the 2023 report from NCEES, 8 out of 14 cadets in the Class of 2023 took and passed the Fem exam. After one separation and two successful re-takes, our program is at 10 out of 13, or 76.9%. The national average passing in 2023 was 70.2%, and this is our expected level of attainment. In the previous five years, the pass rates were 91.3% in 2022, 85.0% in 2021, 77.8% in 2020, 100% in 2019, and 85.7% in 2018. Our running average over those previous five years is $88.0\% \pm 8.3\%$ (versus $74.4\% \pm 2.2\%$ for the national average).

Note: We are **above** the national average for the pass rate for the past six years even including the one separated cadet, and we assess our program against the national average, which 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.” 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of the 14 cadets, 13 said that they strongly agreed (score = 5/5), with one cadet replying that they were neutral (score = 3/5). This equates to a mean score of $4.88/5.00 \pm 0.54$ for the 14 cadets participating in the survey. 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

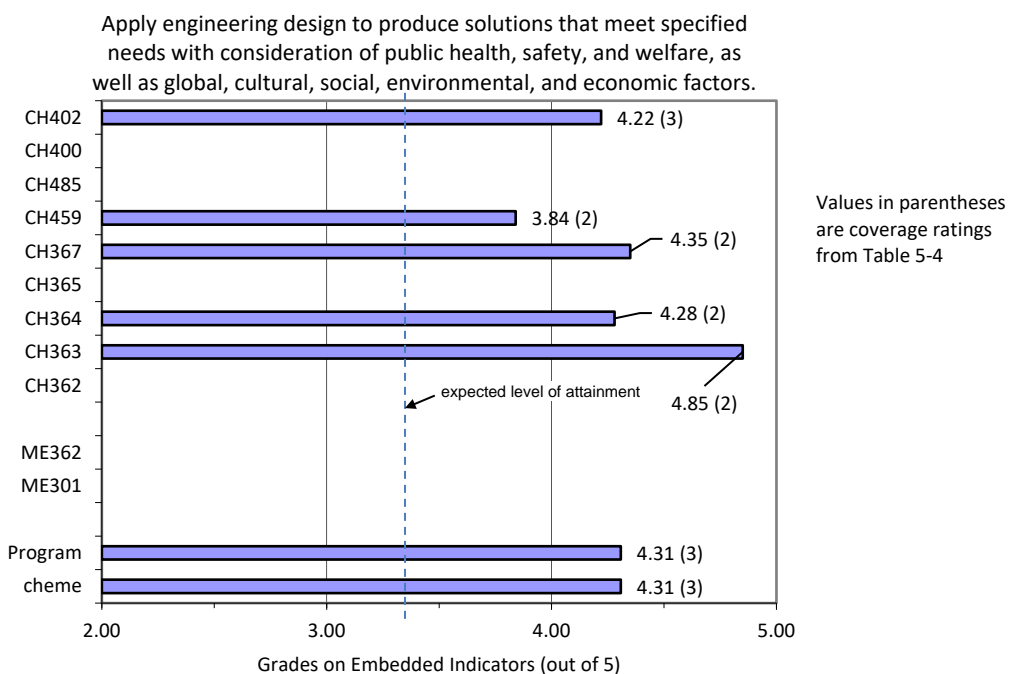


Figure 2-1. Coursework Embedded Indicator results for Student Outcome 2.

2. End of Semester Student Surveys

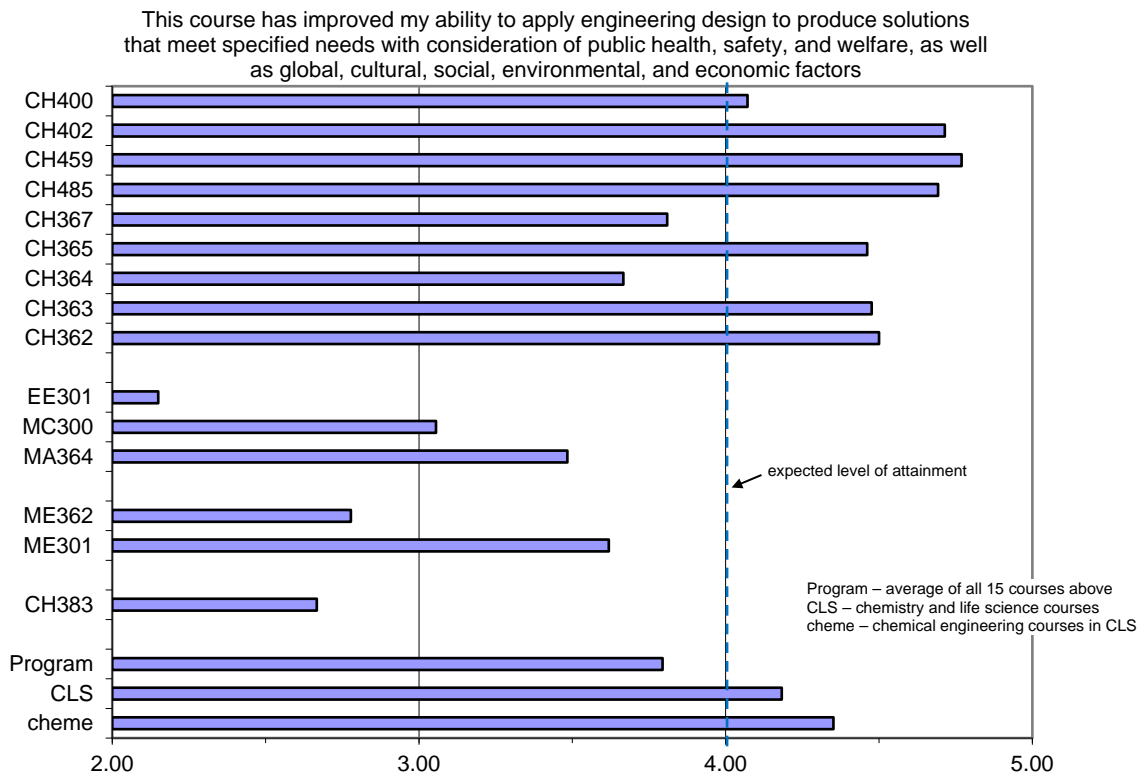


Figure 2-2. End-of-Semester Student Survey responses for Student Outcome 2.

- The average course grade in CH402 Chemical Engineering Process Design was 3.44 ± 0.55 ($n=13$) in AY23, compared to 3.33 ± 0.50 ($n=23$) in AY22, 3.46 ± 0.68 ($n=20$) in AY21, 3.26 ± 0.70 ($n=29$) in AY20, 3.27 ± 0.92 ($n=21$) in AY19, and 3.37 ± 0.66 ($n=19$) in AY18. The 5-year running average for the previous five years is 3.34, and this is our expected level of attainment. This year's score was *above* the 5-year running average.
- 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." 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of these, 13 out of 14 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 9/14 replying that they strongly agreed (score = 5/5), 4/14 replying that they agreed (score = 4/5), and 1/14 that they were neutral (score = 3/5). This equates to a mean score of $4.57/5.00 \pm 0.65$ for the 14 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

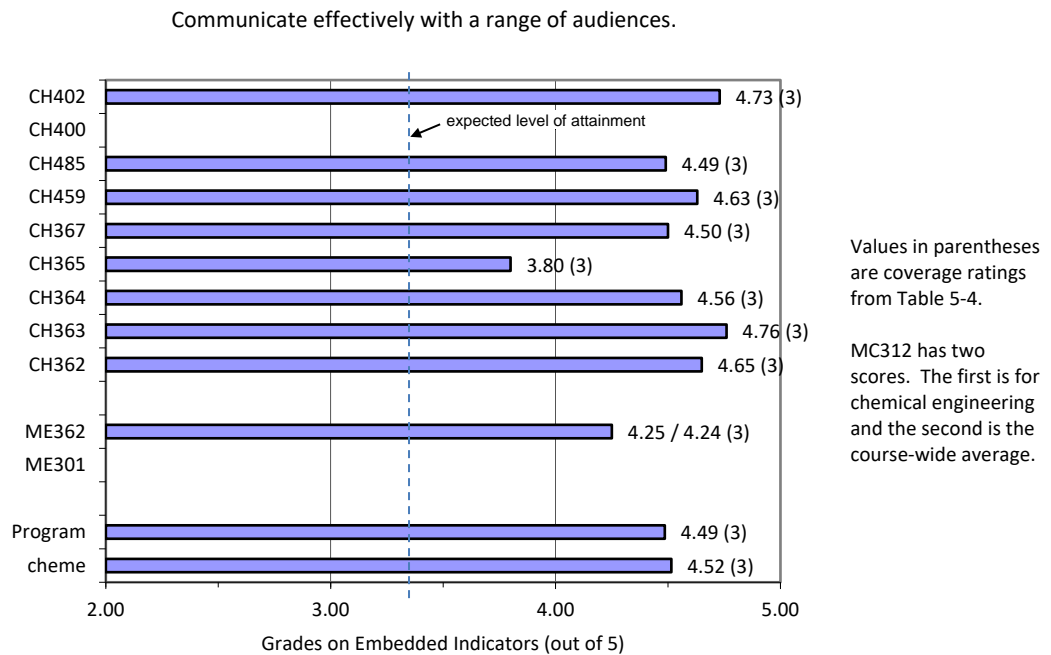


Figure 3-1. Coursework Embedded Indicator results for Student Outcome 3.

2. End of Semester Student Surveys

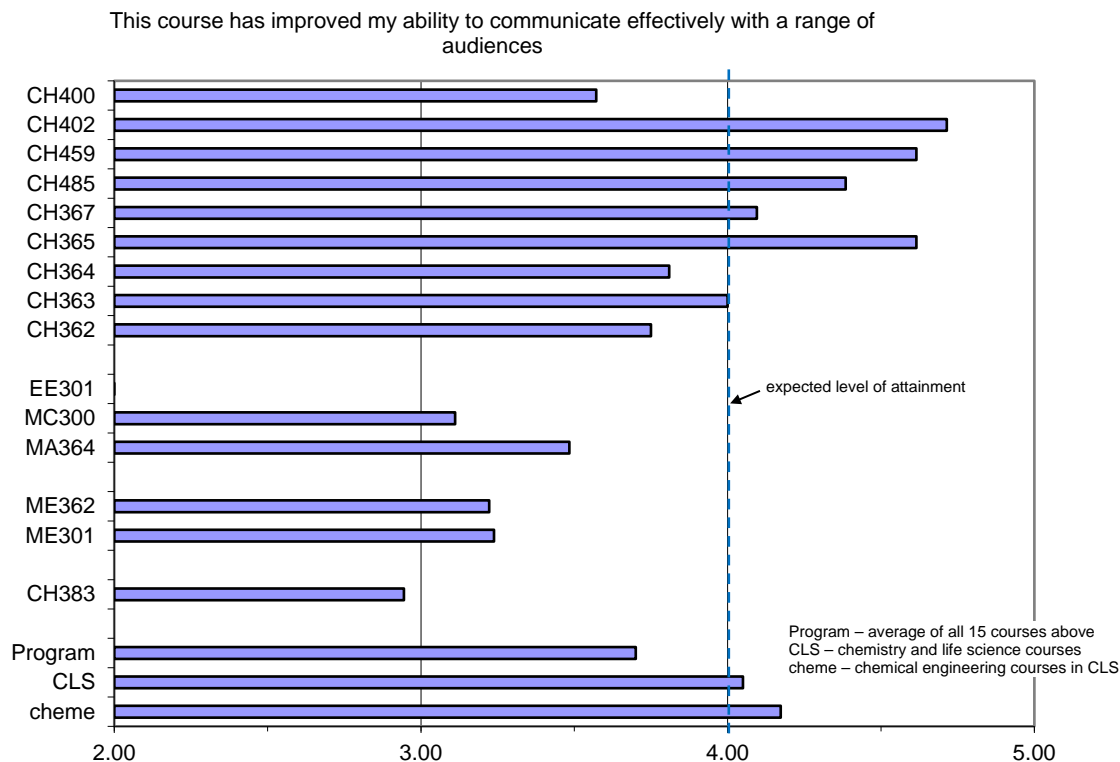


Figure 3-2. End-of-Semester Student Survey responses for Student Outcome 3.

3. The average course grade in CH459 Chemical Engineering Laboratory was 3.41 ± 0.53 ($n=13$) in AY23, compared to 3.80 ± 0.50 ($n=23$) in AY22, 3.67 ± 0.75 ($n=20$) in AY21, 3.53 ± 0.48 ($n=29$) in AY20, 3.52 ± 0.44 ($n=21$) in AY19, and 3.42 ± 0.64 ($n=19$) in AY18. The 5-year running average is 3.59, and this is our expected level of attainment. This year's score was slightly below the 5-year running average but *well within the standard deviation*.
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." 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of these, 14 out of 14 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 10/14 replying that they strongly agreed (score = 5/5), and 4/14 replying that they agreed (score = 4/5). This equates to a mean score of $4.71/5.00 \pm 0.47$ for the 14 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

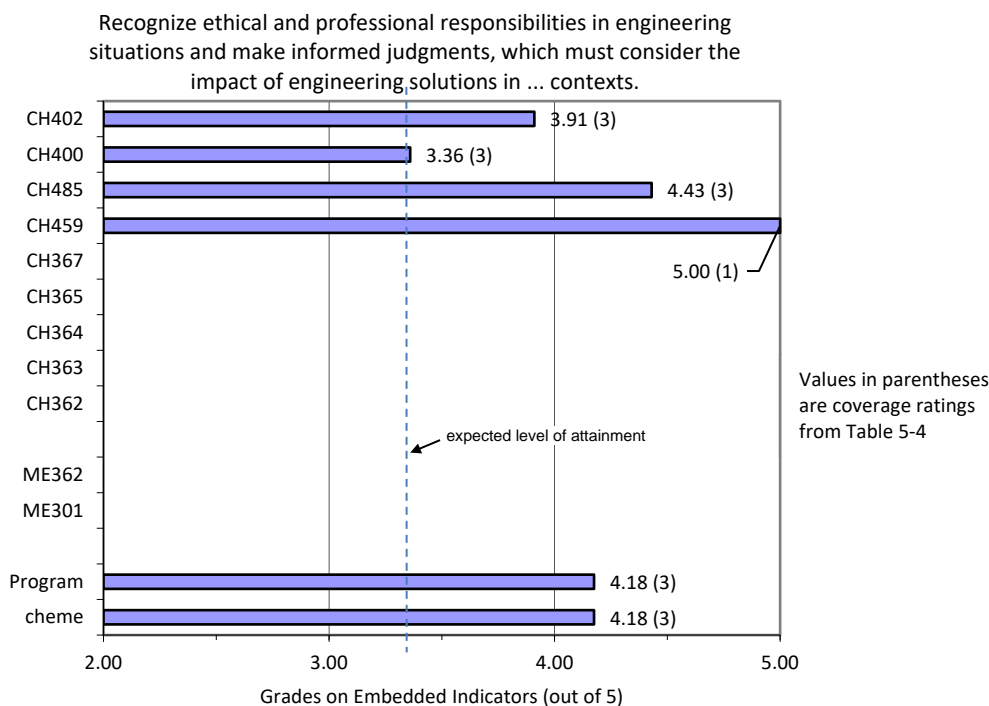


Figure 4-1. Coursework Embedded Indicator results for Student Outcome 4.

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	11.1 ± 4.4
Economics	4	4	7.6	9.7 ± 3.4

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

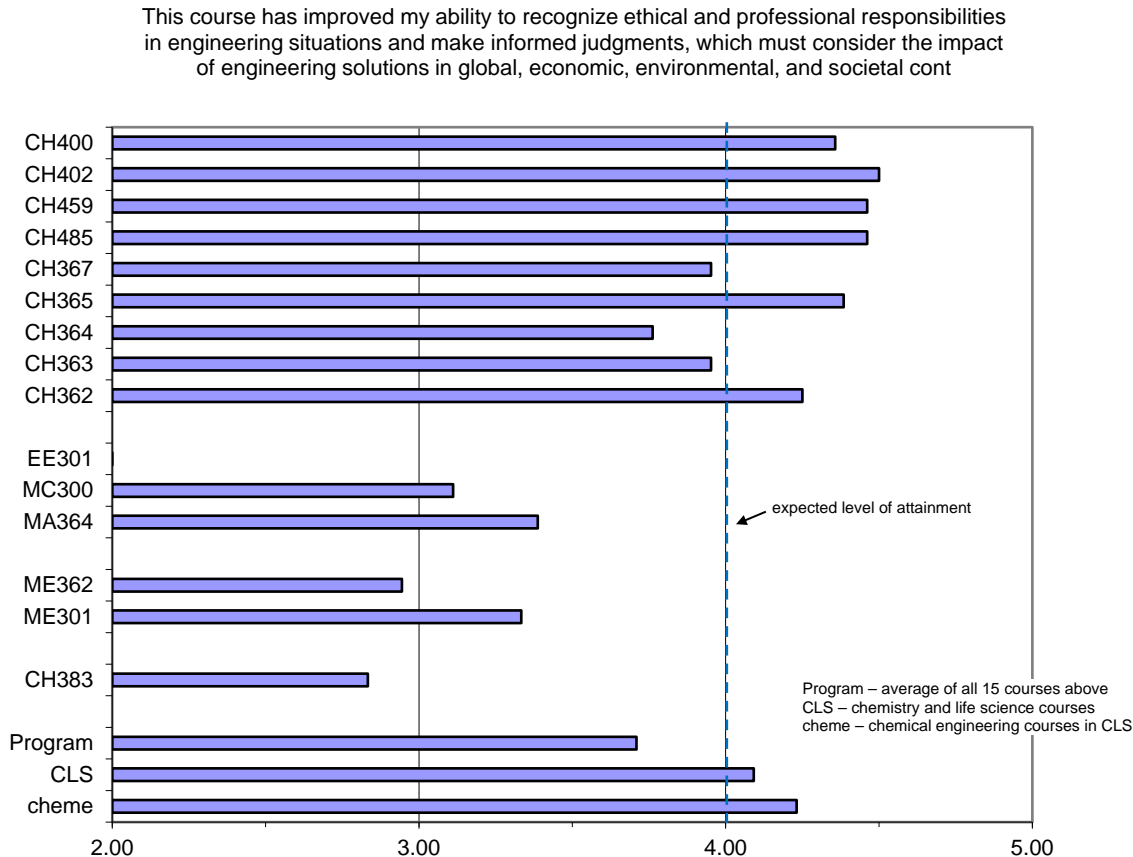


Figure 4-2. End-of-Semester Student Survey responses for Student Outcome 4.

4. Chemical Engineering Program Exit Survey. This survey is given to the Firsties at the end of their last semester. Cadets were asked to respond to 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.” 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of these, 13 out of 14 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 6/14 replying that they strongly agreed (score = 5/5), 7/14 replying that they agreed (score = 4/5), and 1/14 replying that they were neutral (score = 3/5). This equates to a mean score of $4.36/5.00 \pm 0.63$ for the 14 cadets. The expected level of attainment 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 23 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

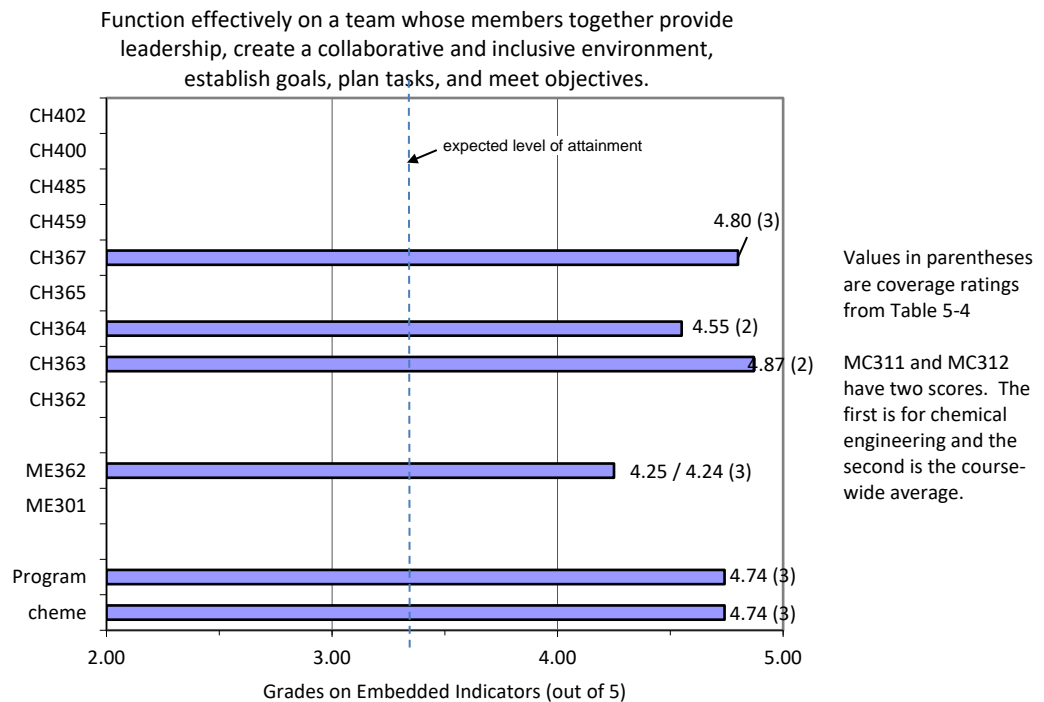


Figure 5-1. Coursework Embedded Indicator results for Student Outcome 5.

2. End of Semester Student Surveys

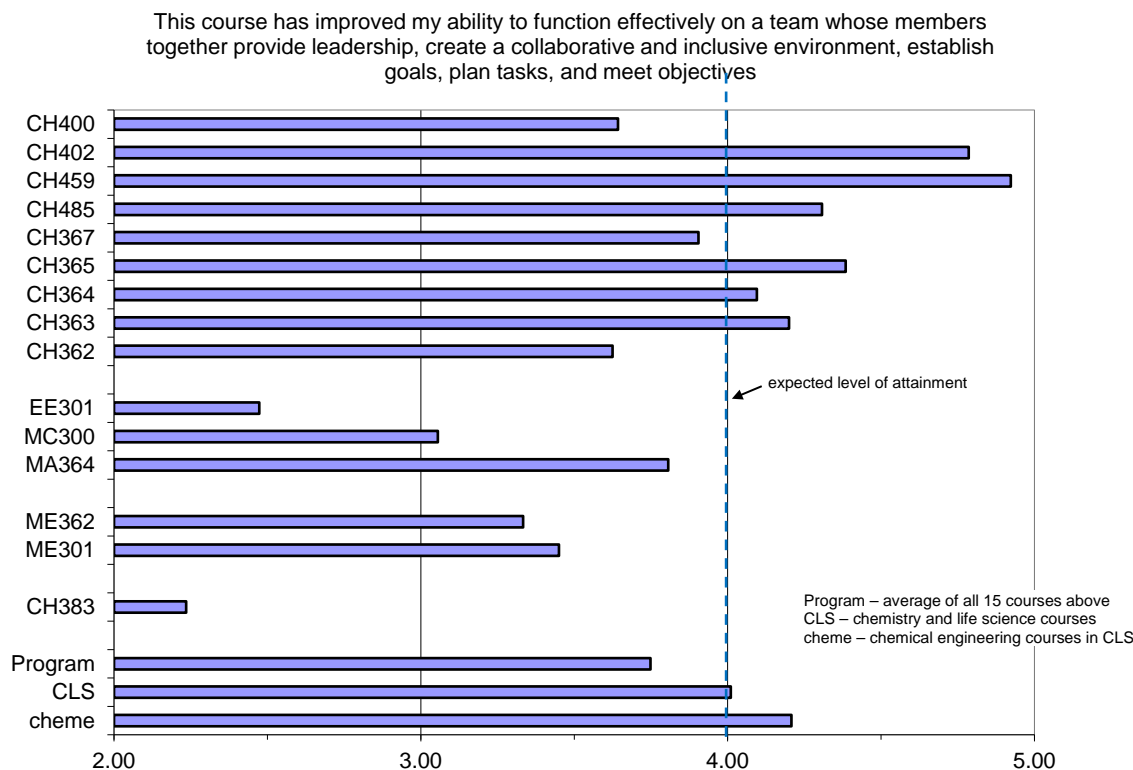


Figure 5-2. End-of-Semester Student Survey responses for Student Outcome 5.

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.” 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of these, 13 out of 14 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 10/14 replying that they strongly agreed (score = 5/5), 3/14 replying that they agreed (score = 4/5), and 1/14 replying that they were neutral (score = 3/5). This equates to a mean score of $4.64/5.00 \pm 0.63$ for the 14 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.	4.7 ^a ±.17 ^c 4.6 ^b ±.21 ^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 ±.12 ^c 4.6 ^b ±.32 ^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 ±.09 ^c 4.6 ^b ±.3 ^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 ±.09 ^c 4.5 ^b ±.19 ^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: AY23, 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.	4.9 ^a ±.02 ^c 5.0 ^b ±0.0 ^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.	4.9 ^a ±.05 ^c 5.0 ^b ±0.0 ^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.	4.9 ^a ±.02 ^c 5.0 ^b ±0.0 ^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.	4.9 ^a ±.05 ^c 5.0 ^b ±0.0 ^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: AY22, 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

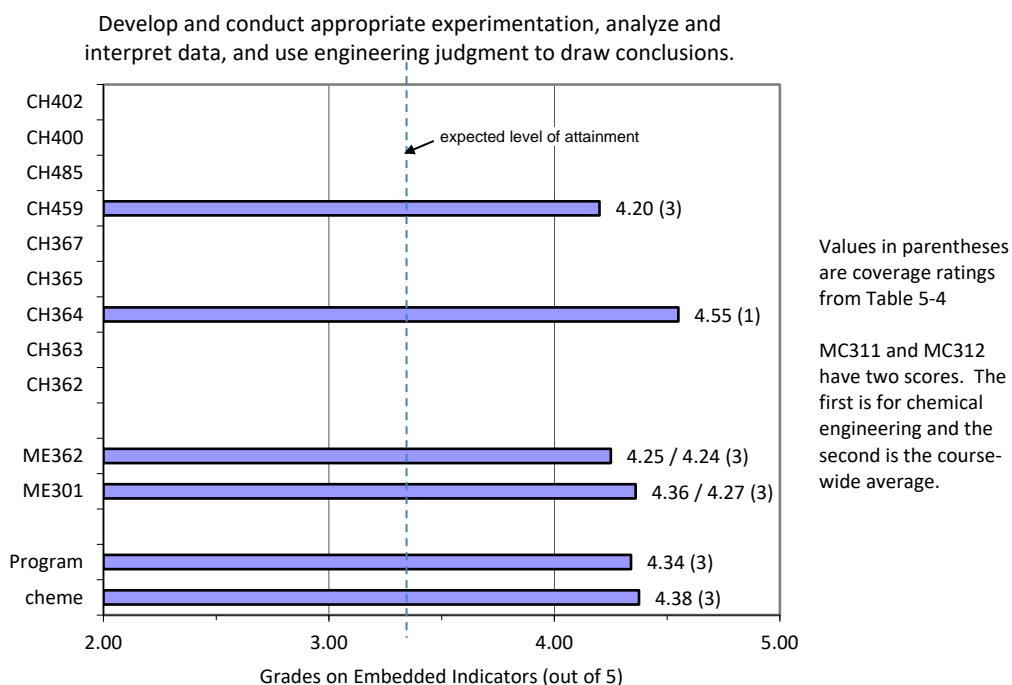


Figure 6-1. Coursework Embedded Indicator results for Student Outcome 6.

2. End of Semester Student Surveys

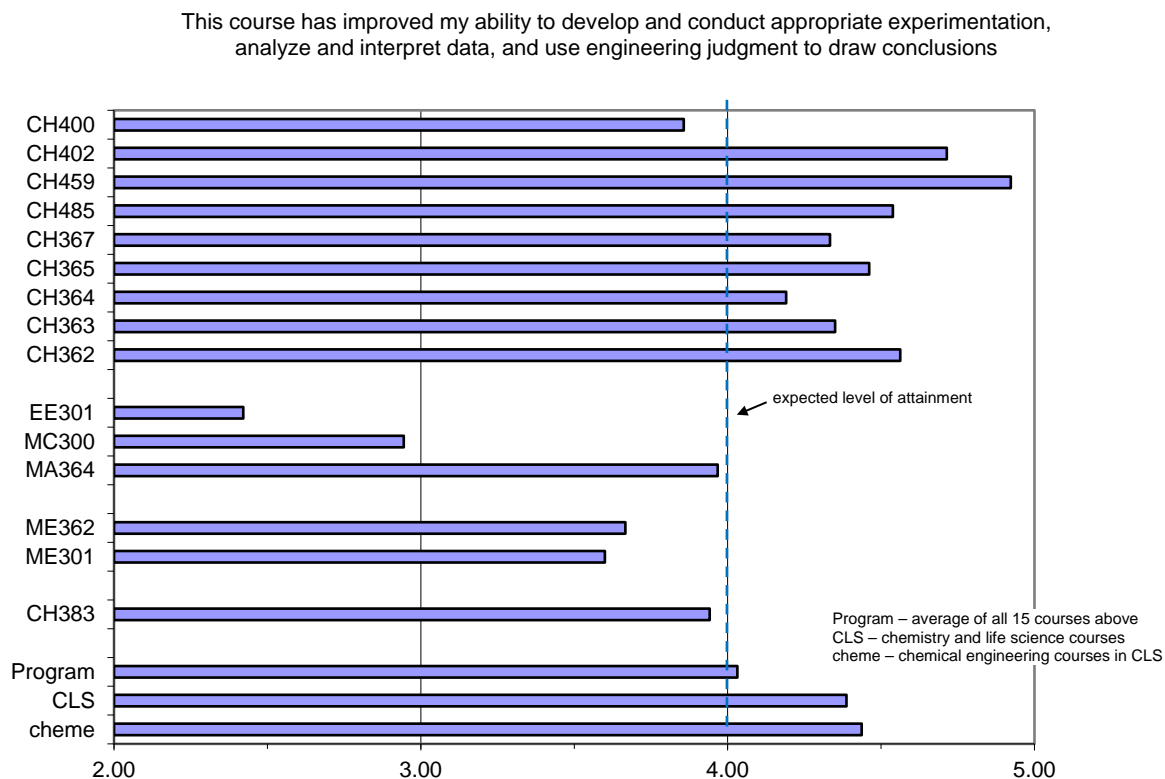


Figure 6-2. End-of-Semester Student Survey responses for Student Outcome 6.

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.” 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of these, 14 out of 14 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 11/14 replying that they strongly agreed (score = 5/5) and 3/14 replying that they agreed (score = 4/5). This equates to a mean score of $4.79/5.00 \pm 0.43$ for the 14 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 3.41 ± 0.53 (n=13) in AY23, compared to 3.80 ± 0.50 (n=23) in AY22, 3.67 ± 0.75 (n=20) in AY21, 3.53 ± 0.48 (n=29) in AY20, 3.52 ± 0.44 (n=21) in AY19, and 3.42 ± 0.64 (n=19) in AY18. The 5-year running average is 3.59, and this is our expected level of attainment. This year’s score was slightly below the 5-year running average but *well within the standard deviation*.

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

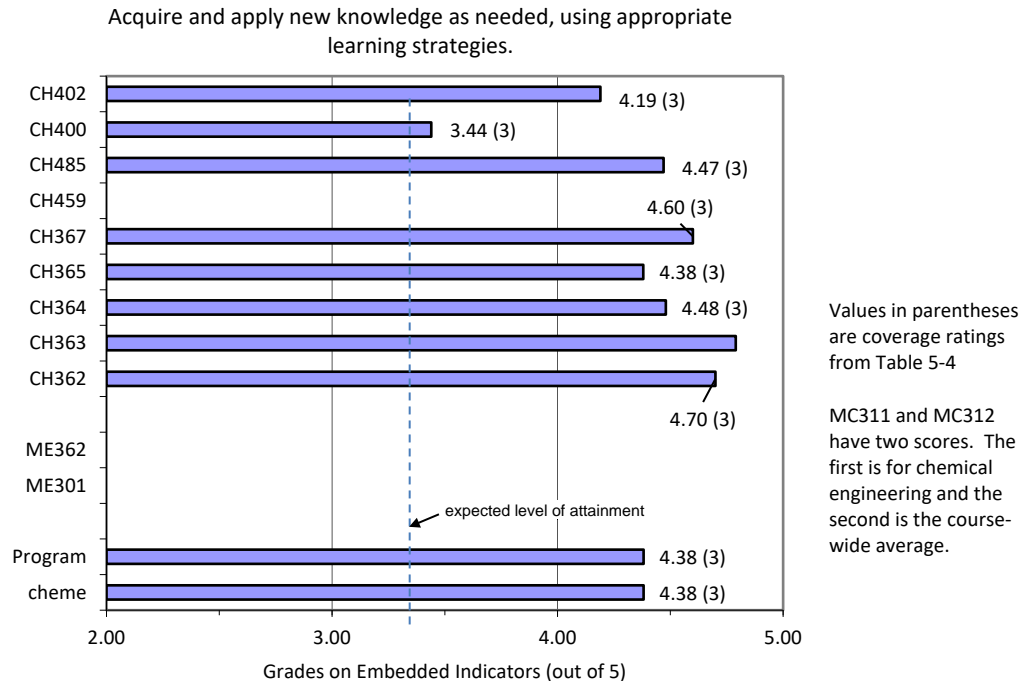


Figure 7-1. Coursework Embedded Indicator results for Student Outcome 7.

2. Percent of Eligible Cadets taking the Fundamentals of Engineering Examination (FEE). For the Class of 2023, 13 of 13 chemical engineering cadets (100% of eligible cadets) prepared for and took the FEE. This compares to 100% in years 2018 and 2019, with 31% in 2020 (9 of 29), and 100% in 2021 and 2022. 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 participants in 2019 to 480 in 2020, which recovered somewhat to 668 in 2021, 600 in 2022, and 521 in 2023. We also recognize that five first-time takers that failed the exam on their first attempt

decided to re-take the exam at their own expense. Note: The participation rate is
EXCELLENT.

3. End of Semester Student Surveys

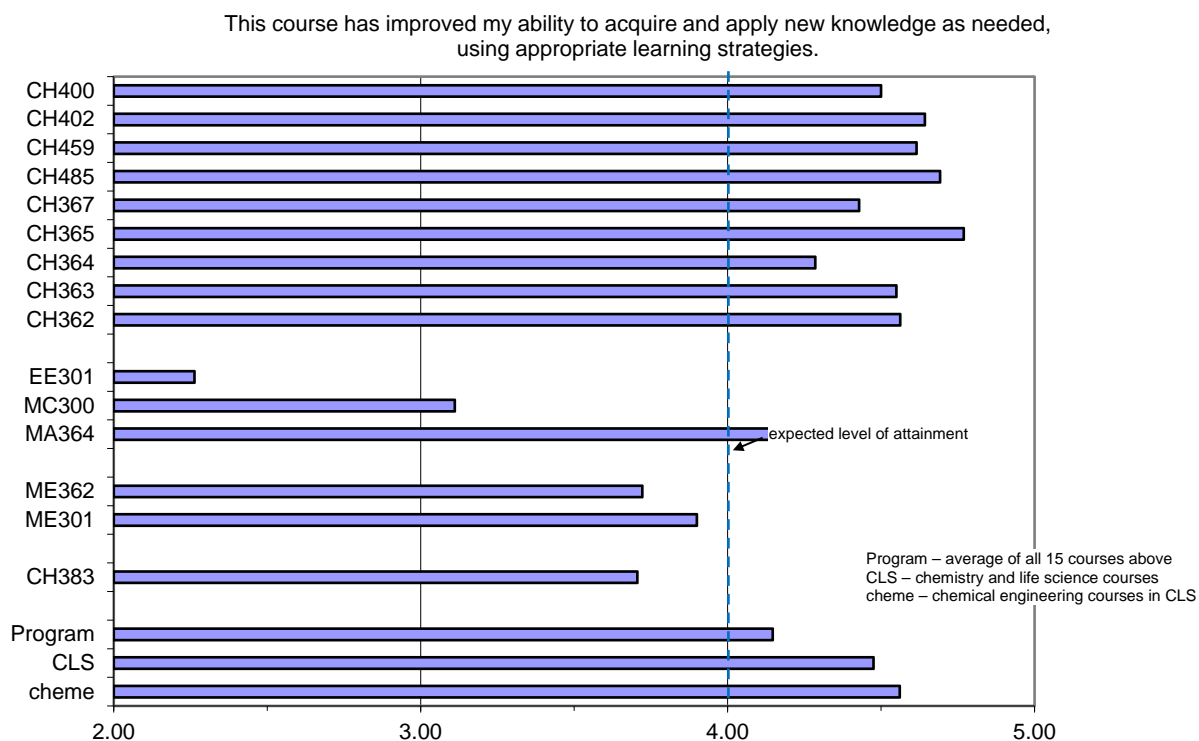


Figure 7-2. End-of-Semester Student Survey responses for Student Outcome 7.

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.” 14 out of 14 cadets completed the survey (one cadet was later separated, so there were 13 graduates). Of these, 14 out of 14 cadets said that they either agreed or strongly agreed (score = 5/5 or 4/5), with 13/14 replying that they strongly agreed (score = 5/5) and 1/14 replying that they agreed (score = 4/5). This equates to a mean score of $4.93/5.00 \pm 0.27$ for the 14 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), then revised 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: Summary, 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.		4.4 ± 0.9	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.	3.6 ± 0.8		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.	3.2 ± 1.3		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.	3.7 ± 1.2		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: Cadet scores were good overall but some grades were held down because some cadets did not read the assignment carefully and ignored the guidance and wrote about Ideas that did not meet rubric requirements. Final Grade: 4.2 ± 1.1 / 5.0					Assignment used for assessment: (e.g., resume draft 1.1 in CH365) resume draft 1.1 in CH365		

Instructor's Name: Biaglow				Cadet Assessed: Summary, 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.	4.9 ± 0.3
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 ± 0.7	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.		4.1 ± 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.		4.5 ± 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: Scores increased with respect to the first draft, especially in Intellectual growth. Instructor was able to provide mentoring and cadets were more introspective regarding previous experiences in chemical engineering courses. Final Grade: 4.4 ± 0.7 / 5.0					Assignment used for assessment: (e.g., resume draft 1.1 in CH365) resume draft 2.1 in CH365		

There is normally improvement in scores in draft 2.1 as cadets incorporate instructor comments to improve and polish their documents. Version 2.1, though, requires articulation of new skills acquired during the semester. Scores can go down if cadets do not show new activities and skills learned during the current semester, and in some individual cases the scores did drop, and intellectual growth (row3) did increase. 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 (follows on page 19).

Instructor's Name: LTC Cowart				Cadet Assessed: All Cadets in CH485 (AY23-1)				
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 re-worded to support a thesis.		4.1 +/- 1.0	Uses multiple substantive examples or scholarly articles in an integrative fashion to support a thesis.	
Technical Competence Outcomes 8	Demonstrates poor or incomplete understanding of technical content.			Demonstrates some knowledge of the technical content, but explanation lacks adequate depth.		3.7 +/- 0.8	Demonstrates exceptional knowledge of technical content.	
Impact of Contemporary Issues Outcome 4	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.		4.1 +/- 0.8	Makes very clear connections between premise and chemical engineering concepts.	
Communication Outcome 3	Writing lacks organization or cohesion. Numerous grammatical errors or errors interfere with meaning. Thesis lacking or implied.			Occasional grammar errors that do not impede meaning. Demonstrates ability to write an essay but lacks cohesion or completeness. Thesis not fully supported.		3.5 +/- 1.0	Demonstrates an ability to effectively communicate in the essay format. Fully supported, clear, concise thesis. Writing style was exceptionally clear and articulate.	
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Cadets met expectations on the draft writing assignment. Cadets demonstrated acquisition of new knowledge and generally wrote in an acceptable format. Technical content with respect to heat & mass transfer can be improved, as well as writing organization. Final Grade: 3.8 +/- 0.9					Assignment used for assessment: (e.g., draft 1 writing assignment 1 in CH485) CH485 Writing DRAFT		

Instructor's Name: LTC Cowart				Cadet Assessed: All Cadets in CH485 (AY23-1)				
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 re-worded to support a thesis.			Uses multiple substantive examples or scholarly articles in an integrative fashion to support a thesis.	4.8 +/- 0.4
Technical Competence Outcomes 8	Demonstrates poor or incomplete understanding of technical content.			Demonstrates some knowledge of the technical content, but explanation lacks adequate depth.			Demonstrates exceptional knowledge of technical content.	4.7 +/- 0.5
Impact of Contemporary Issues Outcome 4	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.	4.8 +/- 0.6
Communication Outcome 3	Writing lacks organization or cohesion. Numerous grammatical errors or errors interfere with meaning. Thesis lacking or implied.			Occasional grammar errors 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 +/- 0.4
Has this cadet demonstrated SO7 (acquiring knowledge)? (Y/N) Y	Comments: Significant improvement from the draft version of the contemporary issues essay. Technical improvement, coupled with extensive discussion of contemporary issues regarding the chosen topic resulted in interesting, thoughtful papers. Final Grade: 4.8 +/- 0.5					Assignment used for assessment: (e.g., draft 1 writing assignment 1 in CH485) CH485 Writing FINAL		

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 – impact of contemporary issues (ability to link contemporary issues to relevant chemical engineering concepts), 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, completed in two drafts. In AY23 (this year), the average for the draft was 3.8 ± 0.9 and the average on the final was 4.8 ± 0.5 , so they achieved a better average on the final than on the draft submission, compared to 3.7 ± 0.8 and 4.7 ± 0.5 in AY22, respectively. The draft and final submissions were graded against the rubric, with the total average score and average scores per outcome shown in the screenshots above. Cadets achieved each of the graded rubric rows with proficiency, and instructor comments are included in the screenshots.

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	7	9.5	9.6±2.7
Material & Energy Balances	8.2	10	8.9	9.3±2.2
Safety, Health, & Environmental	8.3	5	9.5	9.9±3.4
Thermodynamics	8.4	8	8.9	9.1±2.2
Heat Transfer	8.5	8	9.4	9.6±2.5
Fluid Mechanics/Dynamics	8.5	8	9.1	9.4±2.6
Chemical Reaction Engineering	8.6	7	9.1	9.4±2.6
Mass Transfer & Separations	8.7	8	9.4	9.3±2.1
Process Control	8.8	4	8.8	9.4±23.2
Computational Tools	8.9	0	---	---
Economics	8.10	4	7.6	9.7±3.4
Process Design	8.10	7	8.6	9.9±3.4

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	2.64								
CH365	Chem. Eng. Thermo.			3.54						
CH362	Mass & Energy Balances		3.17							
CH363	Separation Processes						3.59			
CH364	Chem. Reaction Eng.					3.38				
CH459	Chem. Eng. Laboratory								3.41	
CH485	Heat and Mass Transfer				3.13					
CH400	Chemical Engineering Sem.									
CH402	Chem. Eng. Process Des.									3.44
MA366	Vector Calculus									
ME311	Thermal-Fluid Systems I			3.33	3.33					
ME312	Thermal-Fluid Systems II			3.18	3.18					
CE300	Fund. Eng. Mech. & Des.									
EE301	Intro. To Elec. Engineering									
CH367	Intr. Auto. Process Control							3.51		
Average Grade 2023		2.64	3.17	3.35	3.21	3.38	3.59	3.51	3.41	3.44
Average Grade 2022		3.15	3.64	3.59	3.47	3.33	3.69	3.42	3.80	3.33
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
<i>Previous 5-year Running Average (Expected level of attainment)</i>		3.00	3.61	3.48	3.30	3.47	3.66	3.43	3.59	3.34
Standard Deviation 2022		0.79	0.59	0.67	0.62	0.53	0.56	0.65	0.53	0.55

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.	4.91 \pm 0.30
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.	4.82 \pm 0.40
3. Communicate effectively with a range of audiences.	4.55 \pm 0.52
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.	4.91 \pm 0.30
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	4.91 \pm 0.30
6. Develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.	4.64 \pm 0.50
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.82 \pm 0.40
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.	4.91 \pm 0.30
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

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.	4.78 \pm 0.44
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.	4.89 \pm 0.33
3. Communicate effectively with a range of audiences.	4.78 \pm 0.44
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.	4.89 \pm 0.33
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	4.89 \pm 0.33
6. Develop and conduct appropriate experimentation, analyze, and interpret data, and use engineering judgment to draw conclusions.	4.56 \pm 0.73
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.	4.78 \pm 0.44
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.	4.67 \pm 0.50
5- Excellent; 4 – Very Good; 3 – Acceptable; 2 – Weak ; 1 – Poor	

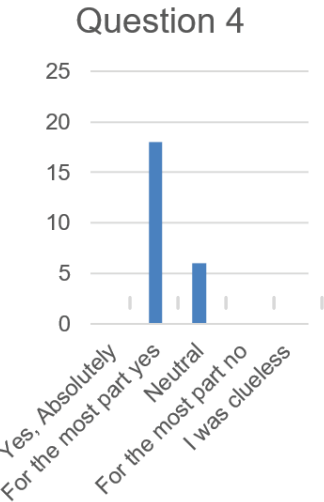
Table 4-4. Summary of Chemical Engineering Student Outcomes Performance.

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	

National, (+/- ~1%):

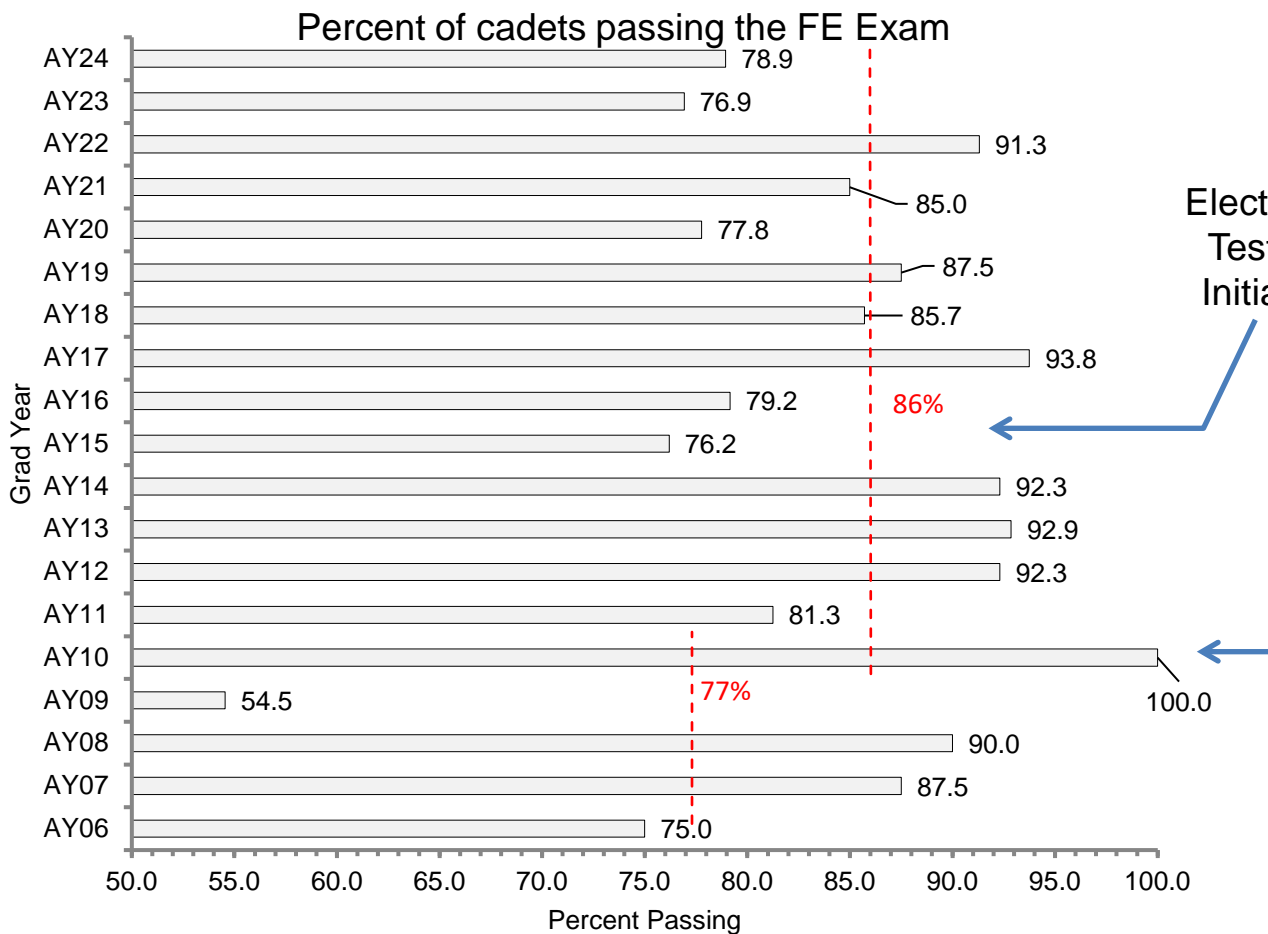
2024	73.2%
2023	70.2%
2022	70.7%
2021	74.0%
2020	74.6%
2019	77.0%
2018	75.0%
2017	74.0%
2016	79.0%

2015	77.4%
2014	89.0%
2013	86.3%
2012	85.1%
2011	87.0%
2010	87.0%
2009	84.0%
2008	87.0%
2007	87.0%
2006	87.0%



Fundamentals of Engineering Exam

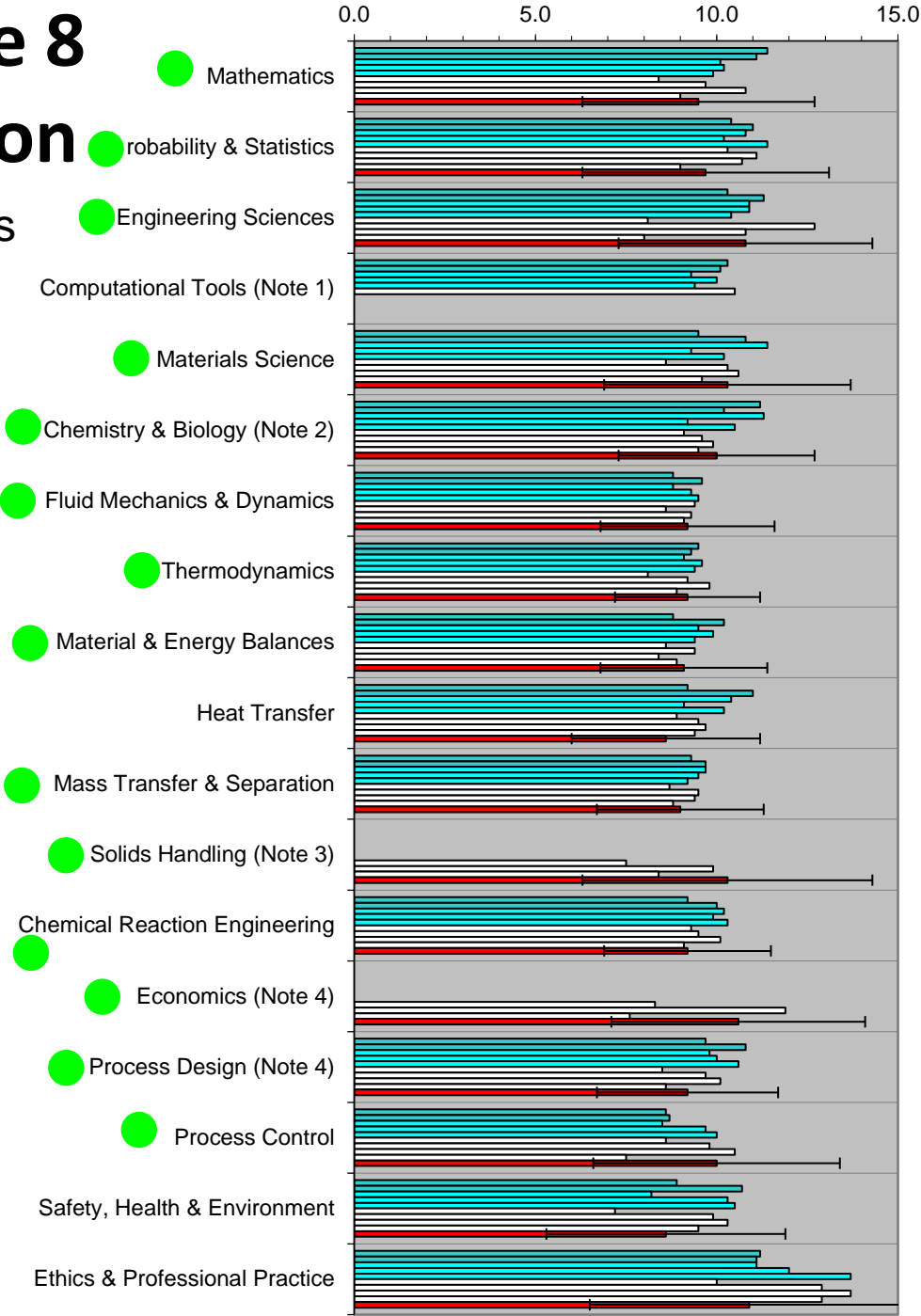
Student Outcome 7: Acquire and apply new knowledge as needed, using appropriate learning strategies



Question 4, Post FEE Survey:
For the questions on the exam
that seemed new to you, were
you able to learn the material
on the spot?

Outcome 8 Evaluation

FEE Results by Topic AY15 to AY24



The error bars are the individual standard deviations for the AY24 data.

The average standard deviation over all data is 3.0.

Good News
labeled with
circles (●) is
from last AY

- Notes:
- (1) This topic
 - (2) "& Biolog
 - (3) New exam
 - (4) Economic
 - (5) Was Proce

Topical Outcomes Evaluation

Deviations from National Averages
AY15 to AY24

Process Control is way up this year.

Mathematics
Probability & Statistics
Engineering Sciences
Computational Tools (Note 1)
Materials Science
Chemistry & Biology (Note 2)
Fluid Mechanics & Dynamics
Thermodynamics
Material & Energy Balances
Heat Transfer
Mass Transfer & Separation
Solids Handling (Note 3)
Chemical Reaction Engineering
Economics (Note 4)
Process Design (Note 4)
Process Control
Safety, Health & Environment
Ethics & Professional Practice

-3.0 -2.0 -1.0 0.0 1.0 2.0 3.0

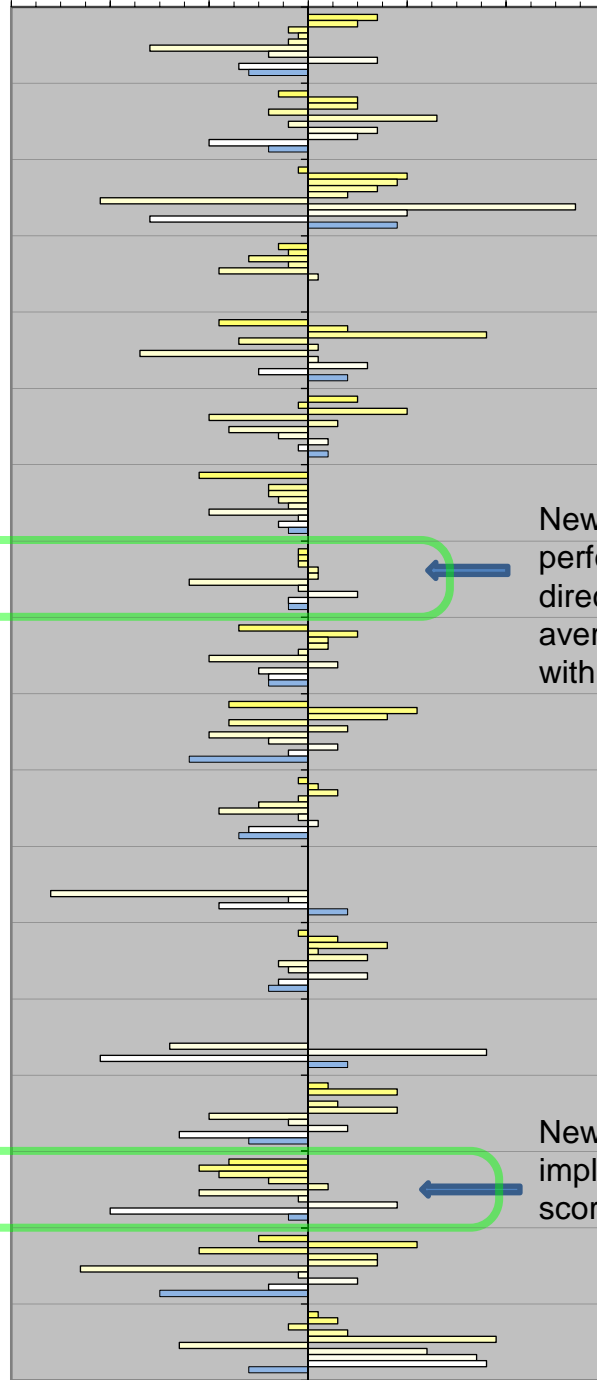
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

New course added in AY13. performance continues in the direction and has been near average for several successful years with a setback in AY20 due to

Notes:
(1) This topic dropped in AY20.
(2) “& Biology” was added in AY21.
(3) New exam question added in AY21. Topic “Economics” was added in AY21. Topic “Design & Economics” was added in AY21 before.

New course added in AY16 implemented in AY19-2. Before scores were always very low.

Expected level of performance is the national average.



Enclosure 6 to 2024 Executive Summary of Chemical Engineering Program Assessment:
 Student Outcomes Mapping of APG-What Graduates Can Do (WGCD)
 CEN1 - Class of 2024

Student Outcome	Communication					Critical/Creative Thinking						Lifelong Learning				Disciplin		
	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	7.1	7.2	7.3
1						XX										XX	XX	X
2						XX	XX		X		X					XX		X
3	XX	XX	XX													X		
4						XX												X
5	X		X		X	XX	XX						X			X	X	X
6										XX					X	XX		X
7					X	XX				X		XX	XX			X		
Total	XX	XX	XX		X	XX	XX		X	XX	X	XX	XX		X	XX	XX	X

Student Outcome	Communication					Critical/Creative Thinking						Lifelong Learning				Disciplin		
	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	3.4	7.1	7.2	7.3
1						4.31										4.31	4.31	4.31
2						4.41	4.41		4.41		4.41					4.41		4.41
3	4.61	4.61	4.61													4.61		
4						4.25												4.25
5	4.68		4.68		4.68	4.68	4.68						4.68			4.68	4.68	4.68
6										4.44					4.44	4.44		4.44
7					4.50	4.50				4.50		4.50	4.50			4.50		
Average	4.65	4.61	4.65		4.59	4.43	4.55		4.41	4.47	4.41	4.50	4.59		4.44	4.49	4.49	4.49

Grade	A+	A	A-	B+	B	B-	C+
GPA	4.33	4.00	3.67	3.33	3.00	2.67	2.33
Scale:	5.00	4.62	4.24	3.85	3.46	3.08	2.69