Electrical Engineering Assessment Plan

NOTE: The assessment plan and results are depicted in the Criterion 3 and Criterion 4 sections of this program's self-study for accreditation under ABET, Inc. These sections are on the following pages

CRITERION 3. STUDENT OUTCOMES

A. Student Outcomes

Our program student outcomes are identical with those listed in ABET "Criteria for Accrediting Engineering Programs", Section I: General Criteria for Baccalaureate Level Programs, Criterion 3: Student Outcomes:

(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Our student outcomes are available to the public at:
http://www.sdsmt.edu/Academics/Departments/Electrical-and-Computer-Engineering/Accreditation---Assessment/

B. Relationship of Student Outcomes to Program Educational Objectives

As discussed in Criterion 2: PEOs, our PEOs are listed below for ease of reference:

1. Graduates will be able to successfully practice Electrical Engineering and related fields regionally, nationally, and globally.
2. Graduates will be well-educated in the fundamental and applied concepts of Electrical Engineering and be able to continue their professional development throughout their careers.
3. Graduates will be skilled in clear communications and teamwork, and capable of functioning responsibly in diverse environments.
4. Graduates will be prepared to demonstrate leadership in outreach, innovation and invention.

The table below shows how our student outcomes prepare our graduates to attain our PEOs.

Table 3-1 Student Outcomes Related to PEOs

CENG Program: Mapping of Student Outcomes to PEOs					
SO		PEO #1: Successful Graduates	PEO #2: Fundamentals, Professional Development	PEO #3: Communication, Teamwork, Diverse Environment	PEO #4: Leadership
a	Knowledge	4	3	2	3
b	Experiments, design - analyze - interpret	4	4	2	2
c	System Design	4	4	2	2
d	Teaming	3	3	4	2
e	Engineering Problems	4	4	2	2
f	Ethics	3	2	4	3
g	Communicate	4	2	4	4
h	Global & Societal context	4	3	3	2
i	Life-long learning	3	4	2	3
j	Contemporary Issues	4	3	2	2
k	Tools	4	4	1	1
	Strength of coverage of each PEO:	3.7	3.3	2.7	2.3

The numbers in the table above indicates the strength of support of the student outcome to the PEO. The strengths are rated from 0 to 4, in a similar fashion as our course outcomes are mapped to student outcomes in Criterion 4:

0 = Not correlated

1 = Little correlation
2 = Modest correlation
3 =Good correlation
4 = Highly correlated

The scoring in the table above was performed after discussions among the Department Head, our ABET program coordinator and one of our faculty who is very knowledgeable of courses and course contents in the program. The table was then reviewed by all faculty. If our PEO achievement falls below an acceptable level (as discussed in Criterion 4 - Continuous Improvement), we can use this table to identify which student outcomes, and from there which particular courses, to strengthen.

Some observations from the strength mapping, and the process used to score each strength:

a) All PEOs are covered by all student outcomes
b) Coverage varies, with PEO #1 scoring the highest (because of the technical nature of our engineering / math curriculum).
c) There is at least one score of 4 (highest) in each student outcome row, which indicates a strong correlation of that outcome to at least one of the PEOs.
d) The weakest correlation is for PEO #4 (Leadership). Leadership is a skill that requires an opportunity to demonstrate leadership before it can be assessed. Although our program offers leadership opportunities in the many CAMP teams, clubs and campus organizations, it is not mandatory that students perform in leadership roles. PEO #4 covers a broad spectrum of leadership (outreach, innovation and invention) which is difficult to quantify and to train for specifically. We know from our own experience that training in the fundamentals, and exposure to a broad range of applications increases the probability of success in innovation and invention, which will likely lead to advancement into technical or management leadership roles.
e) There was a tendency to score every relationship with a "4". Effort was needed to bring the scoring into a broader range.
f) If there was a strong advocate for a particular score, others tended to agree with that advocate's argument without offering strong counter arguments.
g) All PEOs are covered by a strength of at least 2.0 (the average of 5 scores of 0,1,2,3,4).

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Student Outcomes

1. Continuous Improvement Process

Our continuous improvement process is shown in Figure 4-1 "Program Assessment and Evaluation Process". The process is represented as a system with five feedback loops labeled (a), (b), (c), (d) and (e). Each is described briefly below.

Feedback Loop (a):

Purpose: Conduct course, assess student performance and evaluate outcome attainment

Data Collected: This loop represents the traditional course offering, where an instructor teaches the course, issues grades, and evaluates student performance relating to each course outcome. A large number of our courses have been offered for many semesters, and where a particular instructor has been teaching the course multiple times, there is consistency in the material covered by each homework assignment, exam or lab. Instructors teaching required courses are asked to inform the other faculty members when changes in course outcomes are proposed. It is optional for instructors teaching elective courses to bring changes to course outcomes to the faculty. Each instructor has mapped course outcomes to student outcomes a) through k) based on knowledge of course content.

Assessment Method: Each instructor, for each course, uses a combination of indirect assessment (student and instructor post assessment surveys) and direct assessment of selected student work applicable to the outcome under assessment.

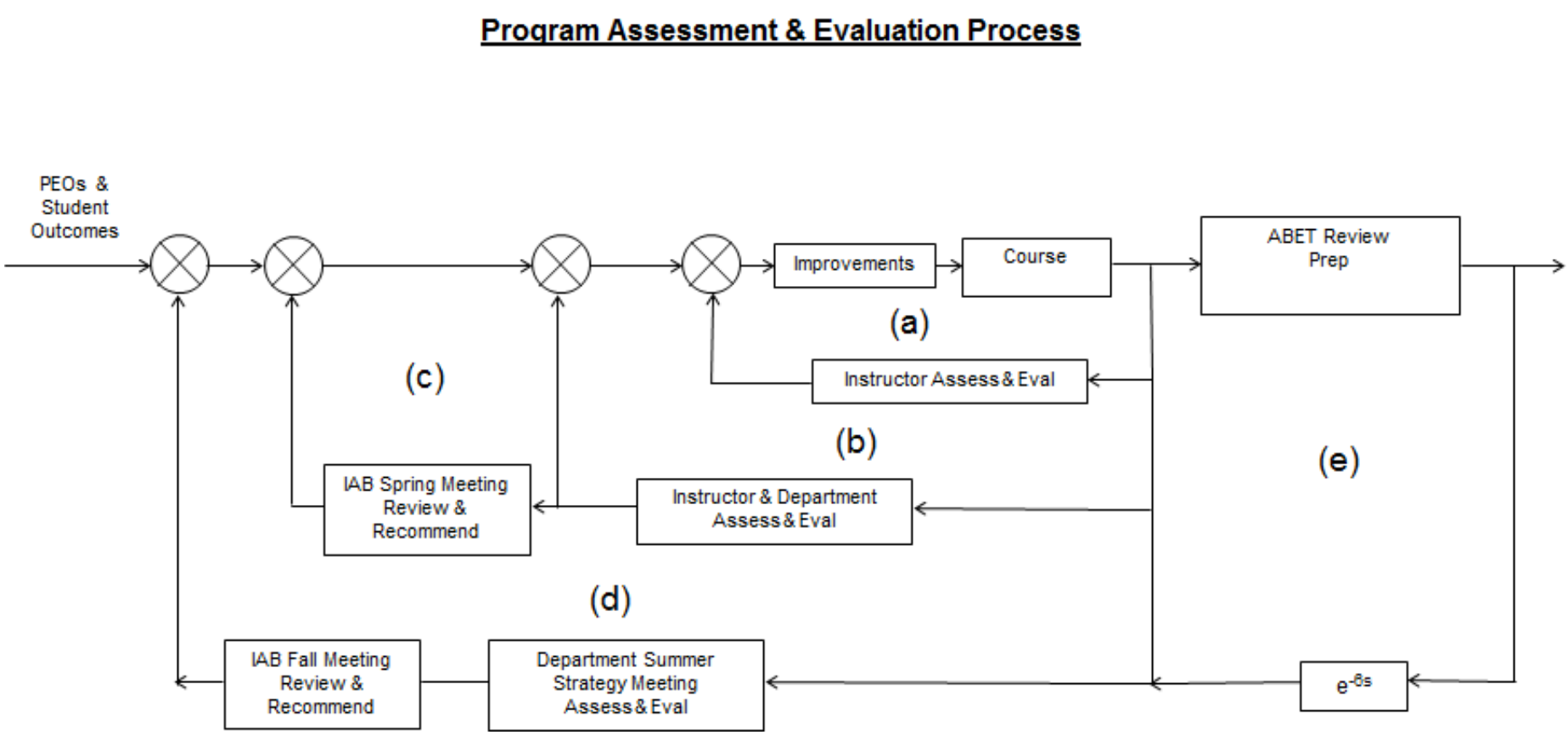
Evaluation Method: We use two courses to evaluate attainment of each a) through i) outcome. Table 5-3, Student Outcomes vs. Courses, indicates which outcomes are covered in each course. For the courses highlighted in ORANGE in Table 5-3, the outcome mapped to that course is evaluated using a rubric. The rubric can range from a traditional 70 / 80 / 90 % grading scoring scheme to a specialized evaluation rubric. Assessments of the outcomes addressed in the courses highlighted in orange are used to determine the overall level of attainment of the outcome in the program.

Evaluation Result: Evaluation consists of using an assessment rubric using selected data from the course. The result is a score indicating the relative attainment of the outcome.

Collection, Assessment & Evaluation Frequency: Every semester.

Expected Levels of Outcome Attainment: Each instructor proposes a performance level to evaluate attainment of the outcome. Instructors typically select an average level of "C" or >70% as a threshold.

Figure 4-1 Program Assessment & Evaluation Process



Results Documented: Each instructor prepares a "post assessment" document of two or three pages. In the year prior to our ABET visit (in this case for fall '15 & spring '16 academic year), we collect in binders the assessment and evaluation materials for each required course and for each student outcome. We also collect samples of student work in the binders. We retain the a) through k) assessment binders from the last ABET visit only (due to space limitations in the department).

Feedback Loop (b)

Purpose: Instructors bring before the department faculty any recommendations resulting from the fall semester to determine if changes need to be implemented in the spring semester.

Data Collected: Data from course outcomes, senior exit survey results.

Assessment Method: Instructor brings discussion and recommendations to the faculty in department meeting.

Evaluation Method: Faculty deliberation in department meeting.

Evaluation Result: Decision regarding issue.

Collection, Assessment & Evaluation Frequency: Once or twice per semester, depending on the effectivity of the change. Decisions which affect other departments need to be brought to the university curriculum committee. Major changes may need concurrence at the SD Board of Regents level.

Expected Levels of Outcome Attainment: Change either is or is not implemented based on faculty decision.

Results Documented: Department meeting minutes.

Feedback Loop (c)

Purpose: Solicit Industrial Advisory Board inputs.

Data Collected: Recommendations from faculty, or request opinion from Employer or Alumni perspective.

Assessment Method: Deliberation in IAB meeting.

Evaluation Method: Consensus after deliberation, or talking the subject over to get Employer or Alumni viewpoints.

Evaluation Result: Recommendation or viewpoint of Employers and Alumni.

Collection, Assessment & Evaluation Frequency: every spring semester

Expected Levels of Outcome Attainment: Expectation of moving forward, or improving.

Results Documented: IAB meeting minutes including meeting handouts.

Feedback Loop (d)

Purpose: Use information from the spring semester to decide on short term issues, and to discuss longer term issues affecting the department.

Data Collected: Faculty suggestions, proposals from the Department Head, senior exit survey results.

Assessment Method: Deliberation

Evaluation Method: Deliberation and Consensus

Evaluation Result: Recommendation or viewpoint of faculty.

Collection, Assessment & Evaluation Frequency: every summer

Expected Levels of Outcome Attainment: Expectation of moving forward, or improving.

Results Documented: Department meeting minutes.

Feedback Loop (e)
Purpose: Use results of ABET evaluation and site visit to implement program improvements.
Data Collected: All materials collected from feedback loop (a) in the academic year leading up to the ABET evaluation and site visit.
Assessment Method: ABET evaluators inspect process and collected data.
Evaluation Method: ABET evaluator team deliberation.
Evaluation Result: Recommendations to the program
Collection, Assessment & Evaluation Frequency: Six years
Expected Levels of Outcome Attainment: Program improvements
Results Documented: ABET evaluators' report

2. Assessment Data Sources

In the "Continuous Improvement Process" section above, the data collected from feedback loop (a) was described as a combination of direct and indirect assessment. Table 4-1 provides additional detail on the data sources for our assessment activities.

Table 4-1. Assessment Data Source Summary

No.	Assessment Source	Direct	Indirect	Formative	Summative
(1)	Faculty Assessment Rubrics Submitted by faculty members for selected courses Data Collected: • Reports/Lab Reports • Presentations • Exams	•		•	•
(2)	Fundamentals of Engineering (FE) Exam Graduation Requirement is that all students take the FE exam.	•			•
(3)	Indirect Student Outcome Assessment Rubrics Collected for selected outcomes. Data Collected: • Student peer assessments • Faculty assessments • Industry assessments		•	•	
(4)	Senior Student Exit Survey Data Collected • Student Self-Assessment of ECE program • Face-to-Face Interview with department head		•		•

(5)	<u>Industry Advisory Board Student Interviews</u> Data Collected • Each IAB meeting student representatives are invited to attend the IAB-Student Panel session and provide candid feedback, which is then summarized/reported back to EE Faculty		•	•	•

3. Frequency for Collection and Evaluation of Data

In the "Continuous Improvement Process" section above, the frequency of data collected from feedback loop (a) was listed as "by semester". Table 4-2 below provides additional detail on the frequency of our data collection activities.

Table 4-2: Frequency for Collection and Evaluation of Data

Outcome	(1) Faculty Assessment Rubrics	(2) National Exam	(3) Indirect Student Outcome Assessment Rubrics	(4)* Senior Student Exit Survey
a	F/S	Su		F/S
b	F/S			
c	F/S		F/S	
d	F/S		F/S	F/S
e	F/S	Su		F/S
f	F/S	Su		F/S
g	F/S		F/S	F/S
h	F/S			F/S
i	F/S			F/S
j	F/S			F/S
k				F/S

We use faculty - produced rubrics to assess and evaluate outcomes in all but outcome k) (Tools). We use over 30 different software tools in our classes from freshmen through senior level classes, in addition to the many dozens of hardware tools. We elected to assess this outcome using our senior exit survey.

We use the FE exam to assess outcomes a) Fundamentals, e) Engineering Problems and f) Ethics.

We elected to use results from student surveys as a secondary method to assess outcomes c), d) and g).

4. Courses Identified for Outcome Assessment

Table 4-3: Student Outcomes and Courses Identified for Faculty Assessment Rubrics

Outcome	Course No	Course Topic
a	CENG 244/244L EE 381	Intro to Digital Systems Hwk and Lab Electric and Magnetic Fields Hwks and Exams
b	EE 314/314L EE 320L/320L	Control Systems Labs Electronics I Labs
c	EE 351/351L EE 464/465	Mechatronics & Measurement System Final Project Senior Design I and II Key Products
d	EE 264L EE 465	Sophomore Design Grade Senior Design II Grade
e	EE 381 EE 382L	Electric and Magnetic Fields Hwks and Exams Applied Electronics Labs
f	EE 220 EE 351	Circuits I Ethics Quiz Mechatronics & Measurement System Ethics Essay
g	EE 320 EE 465	Electronics I Laboratory Notebooks Senior Design II Design Fair and Final Report
h	CENG 264L CENG 464	Sophomore Design Project Needs Statement Senior Design I Essays
i	CENG 447 EE 464	Embedded Design Final Project Senior Design I Essay
j	EE 330	Energy Systems Questionnaire
k		

We have used direct assessment (scores or rubrics) for a) through j).

Table 4-4: Student Outcomes and Courses identified for Indirect Assessment

Outcome	Course No	Course Topic
a		
b		
c	EE 464/465	Senior Design I and II Key Products Audience Assessments
d	EE 264L EE 464/ 465	Sophomore Design CATME Assessments Senior Design I and II CATME Assessments
e		
f		
g	EE 464/465	Senior Design I and II Key Products Audience Assessment
h		
i		
j		
k	--	Senior Exit Survey

Indirect assessments, in the form of rubrics or surveys were used to assess the outcomes listed above in Table 4-4.

B. Continuous Improvement

1. Outcome a) - Fundamentals

Table 4-5 shows the various direct and indirect assessments made for outcome a). The details are included in the outcome a) binder, and summarized below.

Table 4-5: Outcome a) Assessments

Assessment Method	Performance Criteria	Source	Acceptance Criteria
Direct Assessments -	Hwk 2's complement arithmetic	CENG 244	rubric score>=2.0
course based assessments	Hwk Karnaugh Maps	CENG 244	rubric score>=2.0
	Lab-Arithmetic Circuits (adder)	CENG 244	rubric score>=2.0
	Final Exam	CENG 244	rubric score>=2.0
	Eleven Homework Assignments	EE 381	rubric score>=2.0
	Exams	EE 381	rubric score>=2.0
	CAAP	SDSM&T data	scores>=60 (75 percentile)
	Mathematics, Probability & Statistics, Engineering Economics	FE Exam	ratio>.9 consecutive testing periods
Indirect Assessments	Question 7	Senior Exit	score>=3.0 on survey
constituent surveys		Alumni	
		Employer	
		IAB Board	

We use three direct assessments from two courses (CENG 244, EE 381), the FE exam results and CAAP exam results to assess outcome a). We also use one indirect assessment (senior exit survey) to confirm the results of the direct assessments.

CENG244 (Intro to Digital Design) is the first engineering course in the program, and is required for all EEs. Topics covered include binary number systems, boolean algebra, and combinational / sequential logic. An excellent lab section is included which provides familiarization with data sheets, circuit prototyping and debugging.

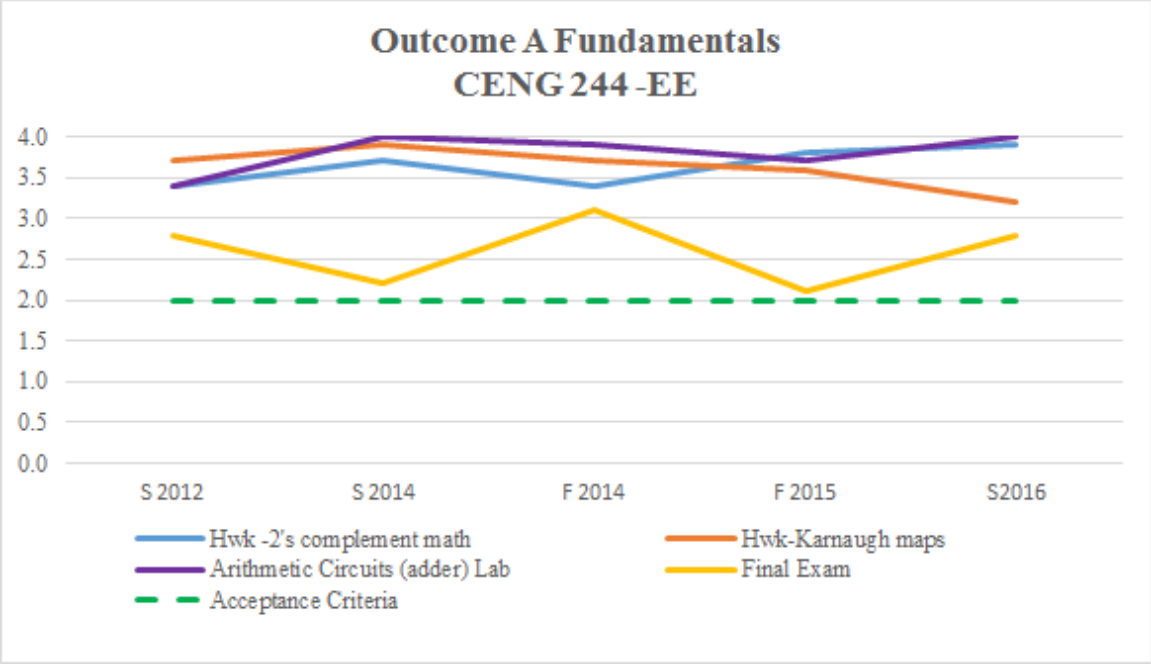
EE381 (Electric and Magnetic Fields) is a required course in the junior year. Applications of such topics as vector algebra, vector calculus, Gauss's Law and Maxwell's equations are used to analyze magnetic and electric fields and related applications. This course is heavily oriented toward mathematics and science, and should demonstrate student achievement of outcome a).

Table 4-6 Data Used for Outcome a) Assessment from CENG 244

CENG 244						
	Score					
Assessment Method	**S 2012**	**S 2014**	**F 2014**	**F 2015**	**S2016**	**Performance Criteria**
Hwk -2's complement math	3.4	3.7	3.4	3.8	3.9	average student grade
Hwk-Karnaugh maps	3.7	3.9	3.7	3.6	3.2	average student grade
Arithmetic Circuits (adder) Lab	3.4	4.0	3.9	3.7	4.0	average student grade
Final Exam	2.8	2.2	3.1	2.1	2.8	average student grade
Acceptance Criteria	2.0	2.0	2.0	2.0	2.0	average student grade

Two homework assignments, a lab assignment and the final exam scores are the data used for this assessment.

Figure 4-2 - Plot of CENG244 Data Used for Assessing Outcome a)



Minimum acceptance criteria is set at 2.0, a level equivalent to a grade of "C".

Figure 4-2 above shows the assessment using data from five semesters. Three different instructors taught this course in the semesters shown. All assessments were above a 2.0 level

regardless of the instructors. The lower curve represents the final exam scores which is consistently lower than the homework and lab scores. Student and instructor surveys at the end of the course indicated that algorithmic state machines, being the last topic covered in the course, seemed to be rushed for both the instructor and the students. Student grades for this topic in the final exam are lower. This appears consistently in the data. We have discussed whether this should be removed from the syllabus and moved to another class or deleted, but concluded that we will keep it in this class, since it will be of value to those students intending to study embedded systems.

Assessment data from EE381 (Fields 1) is shown below:

Figure 4-3 - Plot of EE381 Homework Scores Used for Assessing Outcome a)

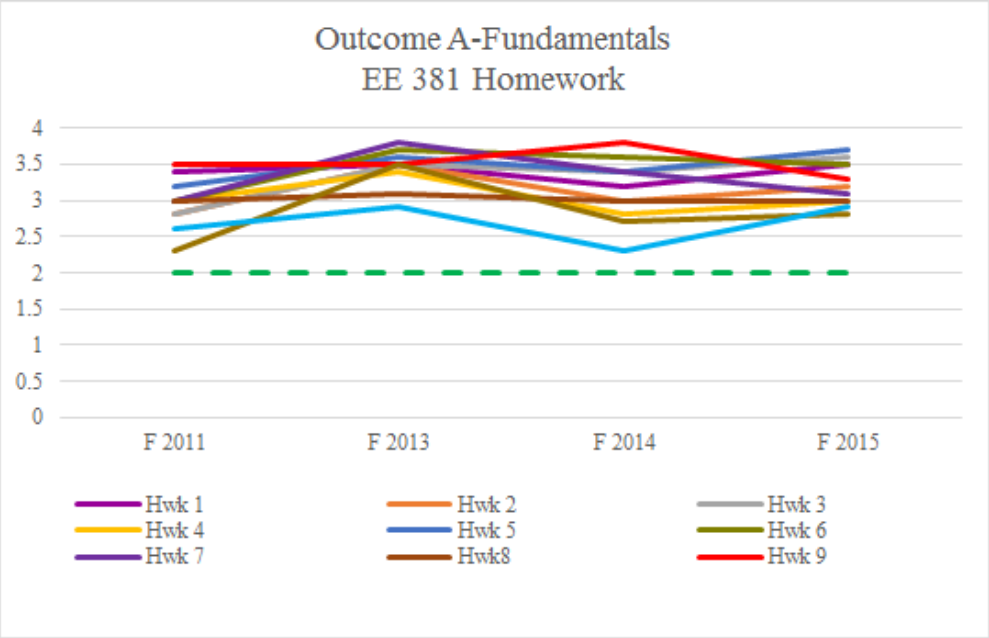
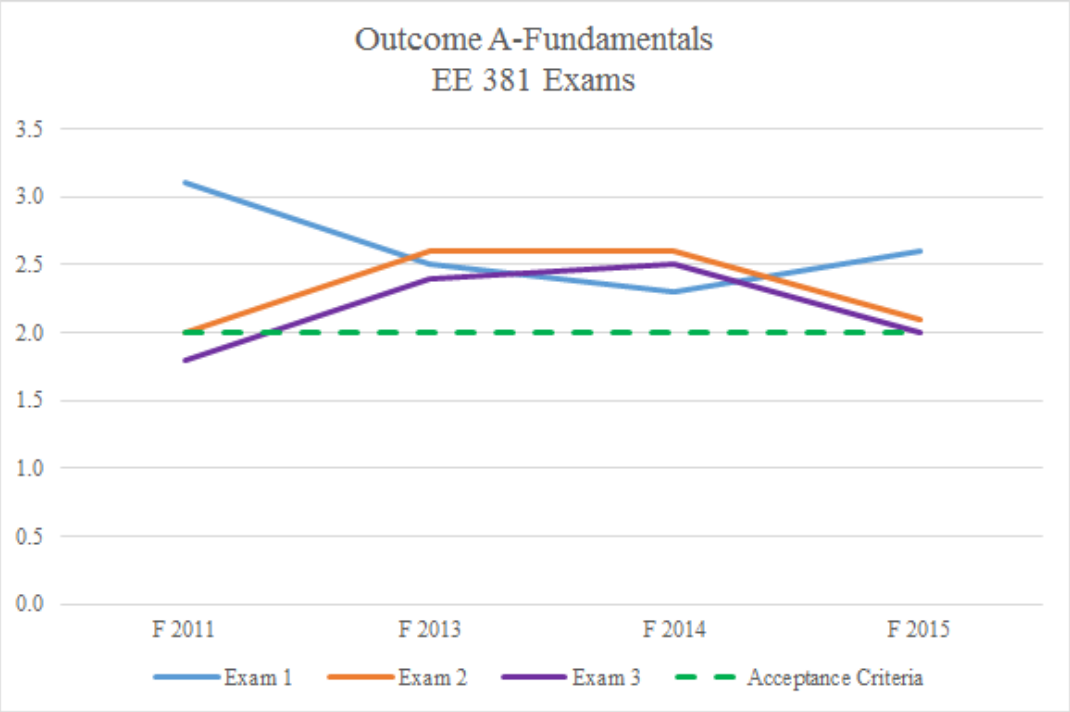


Figure 4-4 - Plot of EE381 Exam Scores Used for Assessing Outcome a)

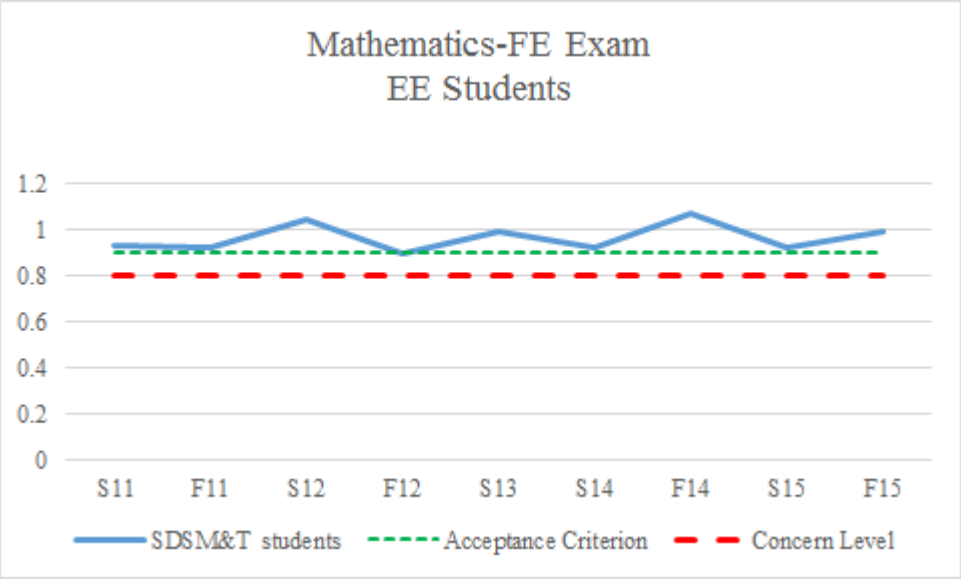


EE 381 data for outcome a) assessment is from both the homework assignments and exams administered in the course. One instructor has consistently taught this course over many semesters. Each homework and exam occurs after the same material is covered consistently over the semesters. The questions are not exactly the same from year to year to eliminate student cheating. However, the same material is evaluated in each of the homework assignments and exams.

Students are generally weak on vector calculus. The pacing of the course is critical, with magnetostatics usually covered only in a cursory manner. Performance could be improved by adding more example problems in certain areas such as boundary condition, more sample problems in general and problems on Ampere's Law. Over the years, the number of quizzes has been increased which seems to motivate students to stay on schedule. Fields is one of the more difficult and more theoretical of the EE courses, and typically students don't have the sophistication in and appreciation of the math background to grasp it deeply.

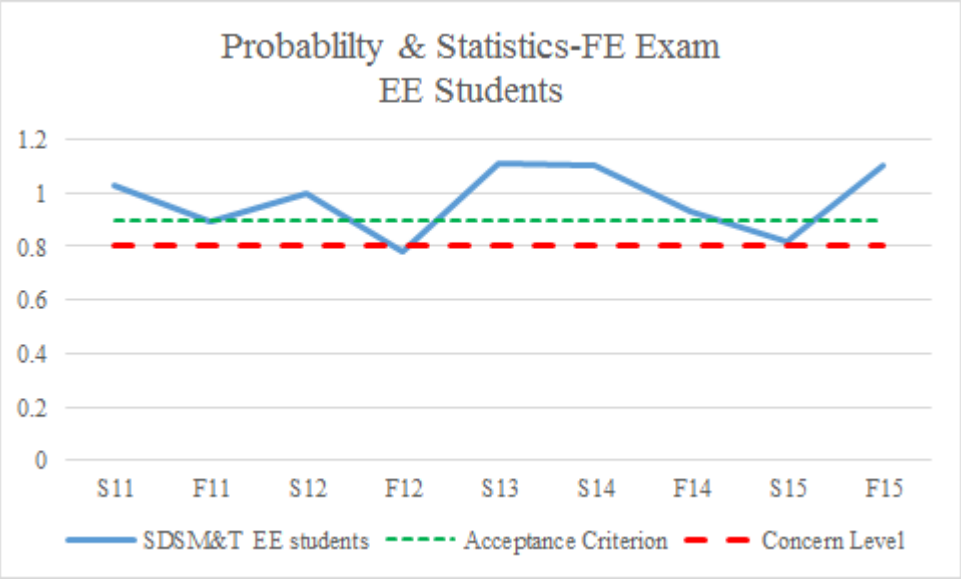
The FE exam results were used to assess three components of outcome a): knowledge of probability & statistics, basic mathematics and engineering economics. Results are shown in the three charts below.

Figure 4-5 Mathematics Assessment Using FE Exam Results



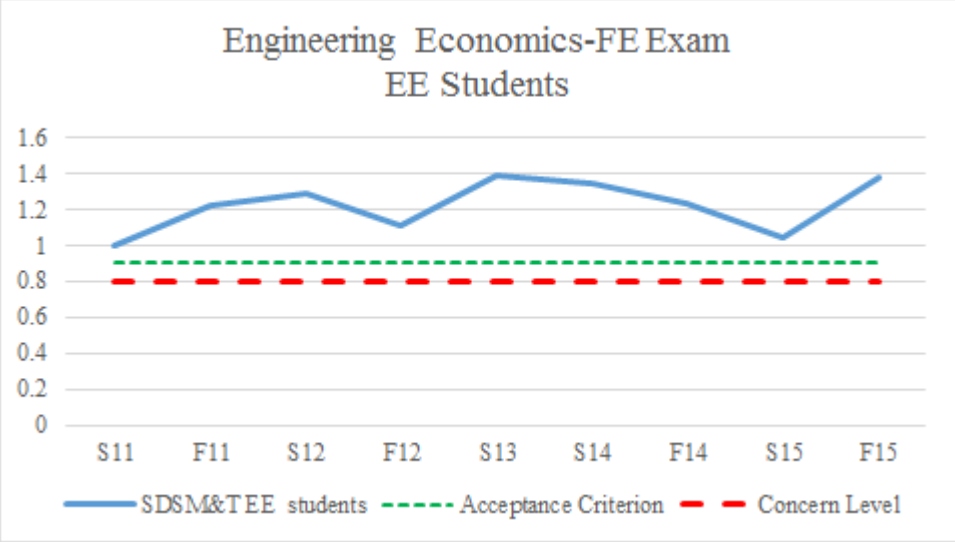
We see that our students perform slightly below, or at the national average in mathematics. The university is planning to implement a new math program called "MathSpark", which is focused on increasing the math proficiency of our incoming freshmen. In future semesters, we will be able to see if this program moves our math scores higher.

Figure 4-6 - Probability & Statistics Assessment Using FE Exam Results



Our EE graduates are generally above the national average in this category.

Figure 4-7 - Economics Assessment Using FE Exam Results

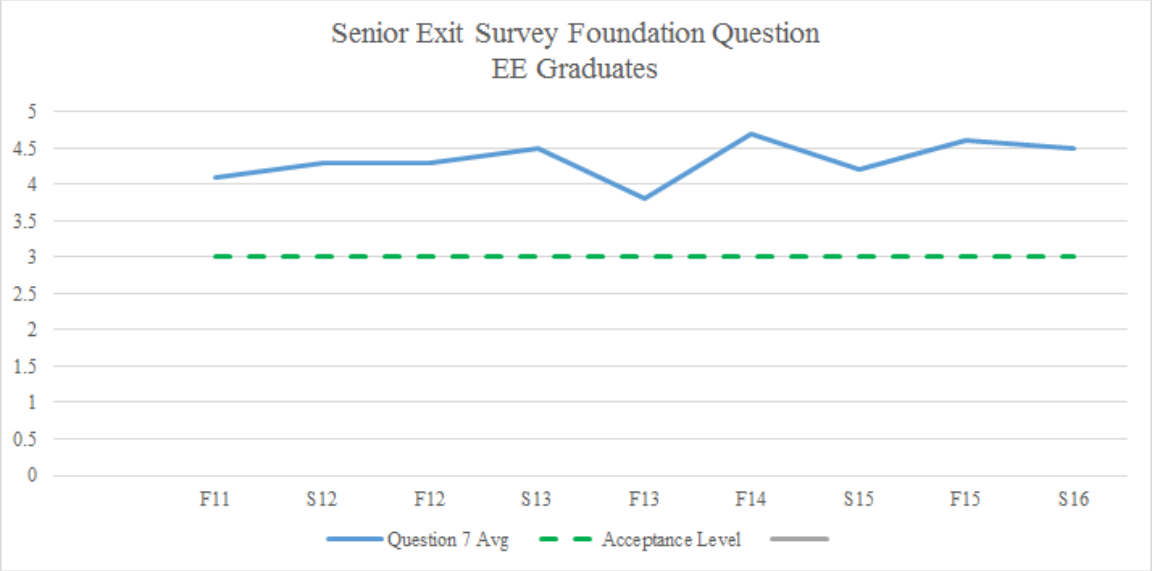


Our EE graduates are generally above the national average in this category.

From the above assessment data, we concluded that our EE students are meeting student outcome a), Fundamentals. Details are included in our outcome a) binder, which will be available at the site visit.

An indirect assessment using our senior exit survey data is also used assess outcome a).

Figure 4-8 - Foundation Assessment Using Senior Exit Survey



Our seniors feel that they are well prepared going out into the job market. Many of them have had intern or co-op assignments and have a sense of what their industry expects in a new hire. Our excellent senior placement rate also indicates, with companies returning to hire our graduates every year, that our students are performing well once they enter the workforce.

2. Outcome b) - Experiment / Analyze

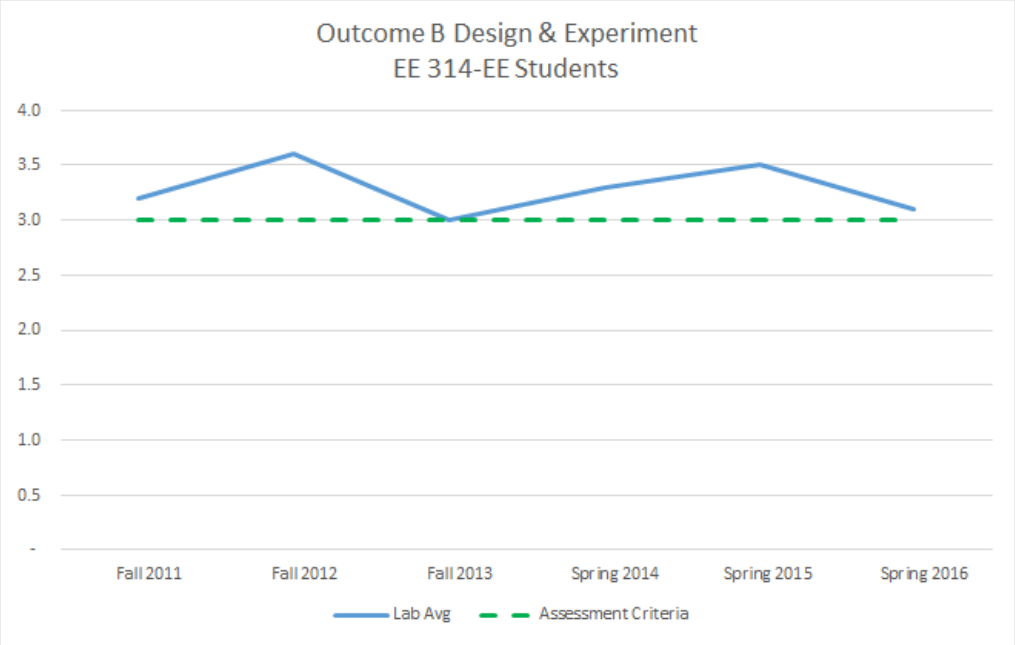
We have selected two direct assessments for outcome b): the labs from EE320 (Electronics 1) and EE314 (Control Systems). These are both required courses in the junior year. We choose these two courses for deeper assessment of outcome b) because these courses have a heavy laboratory content, are higher level courses but yet still contain the fundamental analysis tools and techniques all EE students need to master to be a productive engineer.

Table 4-7 - Assessment of Outcome b)

Assessment Method	Performance Criteria	Source	Acceptance Criteria
Course Based Assessments-	Lab - diode characteristics	EE 320	rubric score>=3.0
(direct assessment)	Lab- zener diode rectification	EE 320	rubric score>=3.0
	Lab-BJT characteristics	EE 320	rubric score>=3.0
	Lab- BJT amplifier	EE 320	rubric score>=3.0
	Lab-NMOS/PMOS FETs	EE 320	rubric score>=3.0
	Lab- Digital Logic Invertor	EE 320	rubric score>=3.0
	Labs- Average lab score	EE 314	rubric score>=3.0
Constituent Surveys -		Alumni	
(indirect assessment)		Employer	
		IAB Board	

EE314 (Control Systems) was a new course number in 2014, but was based on our previous EE311 (Systems) course. The change was made because of a requirement by the Regents that there should be no .5 credit lab courses. The eleven course outcomes associated with the prior EE 311 course have been included in the new EE 314 course. EE 314 has added 2 outcomes associated with the analysis of systems in the frequency domain. All of the variations of the course have shown a heavy emphasis on outcome b) which is demonstrated when fulfilling the course outcome “Be comfortable using MATLAB® as an analytical tool.” The assessment metric will consist of the student average lab grades for each year the course was taught.

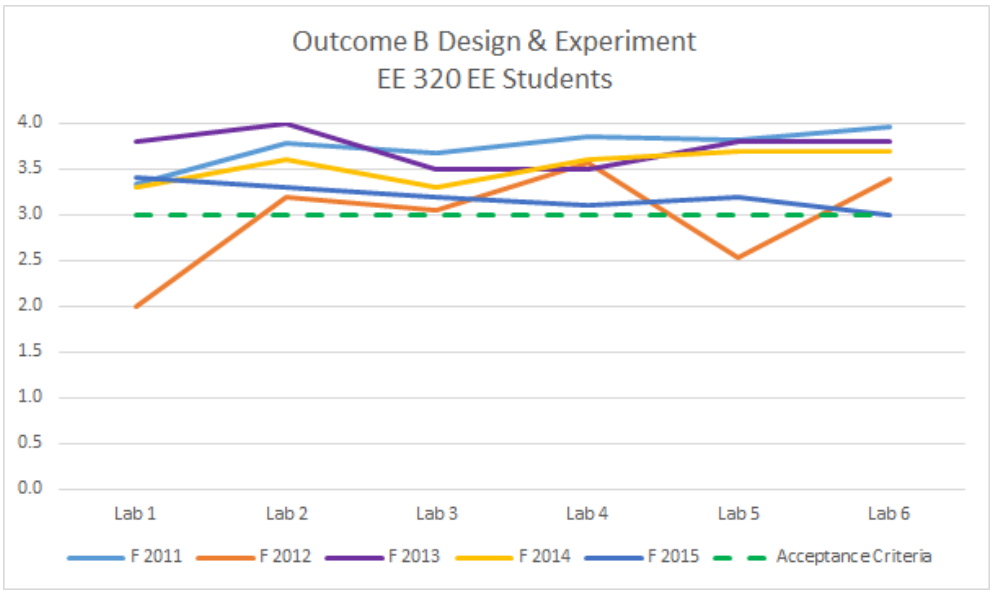
Figure 4-9 - Outcome b) Assessment Using EE314 Lab Grades



An average score of 3.0 was selected as the evaluation criteria. The student interest is high, and the effort required for each lab is significant.

EE320 (Electronics 1) is a four hour required class in the junior year. The course presents concepts of electronic devices and circuits including modeling of semiconductor devices, analysis and design of transistor biasing circuits, and analysis and design of linear amplifiers. Use of computer simulation tools and bread boarding as part of the circuit design process is emphasized. Students are introduced to methods for designing circuits that still meet specifications even when there are statistical variations in the component values.

Figure 4-10 - Outcome b) Assessment Using EE320 Lab Grades



The course appears to be well laid out. Labs remain consistent every time the course is taught - with homework and exams being rewritten. Non-linear devices are a new and more difficult concept for students. Added examples have helped to teach that concept. SPICE-simulation program is also a new tool for the students and added tips /examples have been added in F2015 on this tool.

3. Outcome c) - System Design

Direct and indirect assessments, shown in Table 4-8 below, have been selected to assess outcome c).

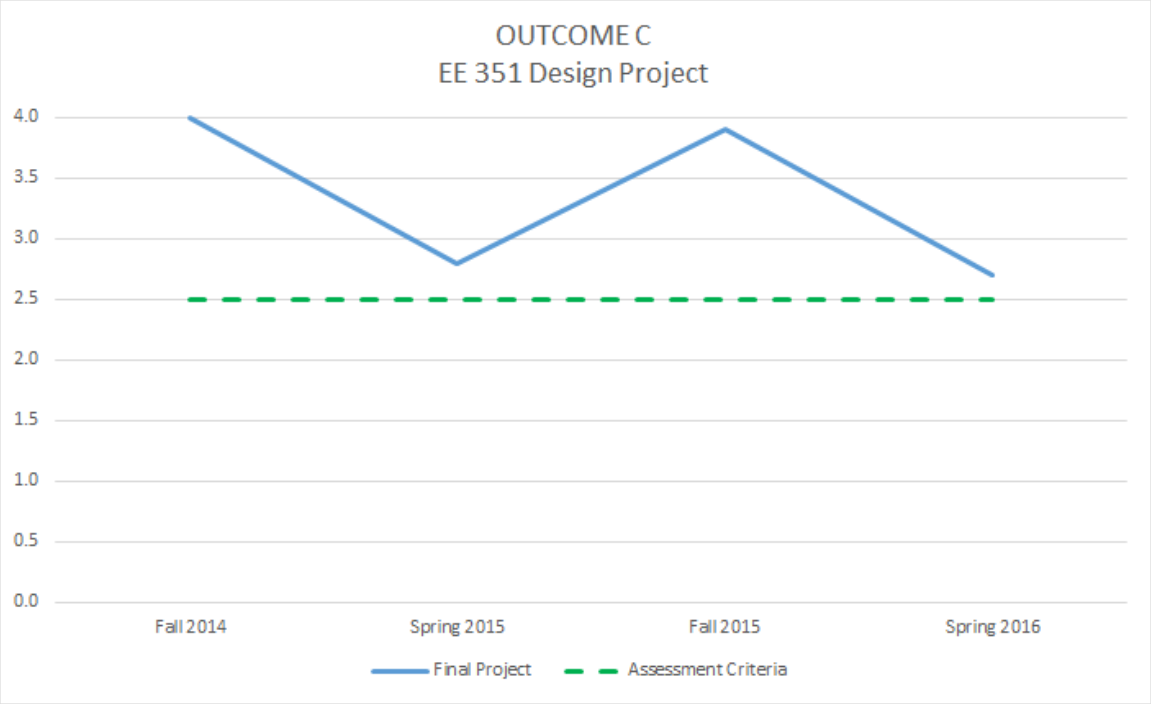
Table 4-8 - Assessment of Outcome c)

Assessment Method	Performance Criteria	Course	Acceptance Criteria
Direct Assessments -	Final lab project	EE/CENG 351	score>=2.5
course based assesments	Preliminary Design Review	EE/CENG 464	score>=2.0
	Req & Spec/Test plan	EE/CENG 464	score>=2.0
	Earned Value Analysis	EE/CENG 464	score>=2.0
	Written final design research paper/final grade	EE/CENG 465	score>=3.0
	Critical Design Review	EE/CENG 465	score>=3.0
	Design Fair Poster	EE/CENG 465	score>=3.0
Indirect Assessments -	Preliminary Design Review	EE/CENG 464	Score of 2.0 out of 4 , meaning developing design skills were observed
constituent assessments- sponsors, peers, advisors	Critical Design Review	EE/CENG 464	Score of 3.0 out of 4, meaning design skills were proficient
	Design Fair Poster	EE/CENG 464	Score of 3.0 out of 4, meaning desgin skills were proficient

The outcome c) binder also contains assessment data from EE220, EE221, EE313, EE320, EE330 and EE362.

The final lab report from EE351 (Mechatronics) is used as a direct assessment.

Figure 4-11 - Outcome c) Assessment Using EE351 Final Report Grades



An assessment criteria of 2.5 was selected. A great deal of effort goes into these lab assignments, and the students seem interested in them so the grades should exceed our minimum level. Spring grades are lower than all grades- it could be attributed to either different teachers (since the course is alternatively taught by the ME and ECE departments), or perhaps students- "spring fever" syndrome.

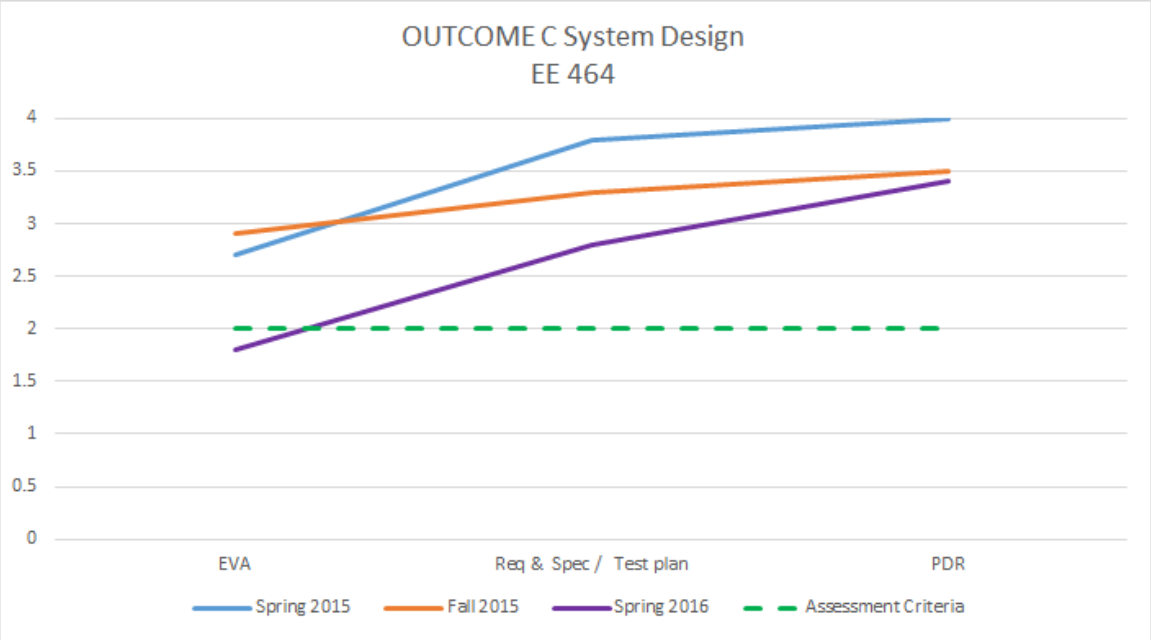
EE464 along with EE465 (Senior Design I and II) is the capstone design experience for graduating EE students. During the design process, students generate several standard work products as they build their final project. Three of these work products per are tracked and evaluated for the direct assessment of this outcome. These items from Senior Design 1 are the Preliminary Design Review report (PDR), the Requirements and Testing document, and the Earned Value Analysis. We selected the Critical Design Review (CDR), Design Fair Poster, and the final paper grades from the final semester.

A final project requiring original design is designed, built, and demonstrated by each student team. Student teams are may select any project of their choosing. The instructor and faculty maintain a list of projects requested from external companies or individuals. Students are encouraged to select a project that is relevant to the industry or company of interest. The final project may involve a team competition such as Moonrockers, Indy Car, Electric Snowmobile or Robotics.

We have used the capstone course sequence for assessment many times in the past, but in 2015 several rubrics were created to formalize the assessment process. Input from student peers and industry representatives, sponsors and advisors is included in the assessment

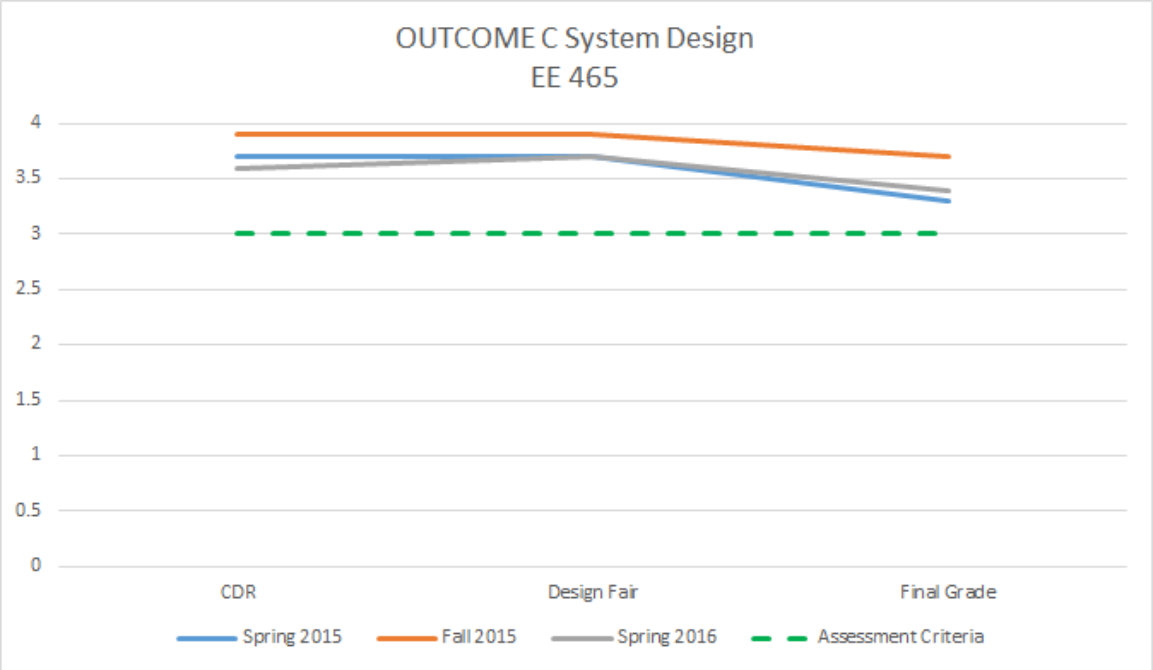
rubric. Assessment of three work products produced in the capstone design process are also used: PDR presentation and report, the CDR presentation and report and the Design Fair Poster. After the initial rubrics were piloted in spring 2015, improvements were included in the rubric used in subsequent semesters. It is planned to have the project advisor review this type of assessment with each design team shortly after the assessment has been completed to provide feedback to the teams. This is particularly useful in identifying teams that have design expectations or schedules that are unreasonable. In previous course evaluations and surveys, students often mentioned that there was a lack of feedback during the course and this is one attempt to remedy this situation.

Figure 4-12 - Outcome c) Assessment Using Senior Design EVA, Spec & PDR Data



The data shown above is consistent with what we see in the course: as performance has been increasing as the students get more familiar with our design process. We have heard comments back from several of our students after graduation that the design processes used in their companies is similar to what we have been using in our capstone process. The design process is a much simplified version of that used in the aerospace / avionics industry.

Figure 4-13 - Outcome c) Assessment Using Sr Des Work Products and Final Grade



An average of 3.0 was selected as the minimum criteria. These are elements are required in real world project design, and a high performance level would benefit the students when they get to their jobs in industry.

We are satisfied with our meeting outcome c). But there are further improvements we want to make in our capstone projects starting in the fall of '16, including deciding on a project earlier, having our PDR and CDR earlier, and allowing more prototyping and experimenting before the design and implementation are frozen as these major design reviews.

4. Outcome d) - Teaming

The chart below indicates that we've used to assess outcome d). These materials are included in the Outcome d) assessment binder which will be available for inspection at the site visit.

Table 4-9 - Assessment of Outcome d)

Assessment Method	Performance Criteria	Course	Acceptance Criteria
Direct Assessments	Final course grade	EE/CENG 264	Class average>=3.0 (90%)
Course based assessments	Final course grade	EE/CENG 465	Class average>=3.0 (90%)
Indirect Assessments-	Peer Teaming Rubric-assessment 1	EE/CENG 264	Score of 2.5 out of 5, meaning developing teaming skills were occurring
Peer assessments	Peer Teaming Rubric-assessment 2	EE/CENG 264	Score of 2.5 out of 5, meaning developing teaming skills were occurring
	Peer Teaming Rubric-assessment 1	EE 464/465	Score of 2.5 out of 5, meaning developing teaming skills were occurring
	Peer Teaming Rubric-assessment 2	EE 464/465	Score of 2.5 out of 5, meaning developing teaming skills were occurring
Constituent Surveys	Question 11	Senior Exit	Sore>=3.0
		Alumni	
		Employer	
		IAB Board	

EE264 is taught as the first multi-disciplinary teaming experience for EE students. It is taught in conjunction with the Mechanical Engineering Dept. Teams are created with students consisting of all three disciplines (EE, CENG & ME). Historically the course is considered successful and an "A" is achieved if the team project operates for the purpose intended, and preliminary and final design reports are completed.

Prior to 2015, metrics have been collected by merely tracking the final grades of the students. In an effort to provide a better teaming experience for the students and allow for a better teaming assessment, a peer critique assessment process has been added in 2015. The initial iteration of the peer assessment was a locally designed rubric that was given to team members well into the semester to determine if the teams were functioning adequately. This rubric did not include student names and was not part of their overall grade. It is instead an attempt to discover how a team is functioning, allow all members a chance to "be heard" by faculty, and if necessary facilitate faculty intervention to correct the problem. A copy of the rubric is included in the outcome binder.

While this attempt helped the teaming experience, the ECE and ME departments decided to move to the nationally recognized CATME teaming assessment method. This assessment consists of each team's members filling out a teaming rubric to assess all members of their team (including themselves). The assessment is done 2 or 3 times during the semester and has the goal of helping students learn to be contributing team members. The CATME survey process flags students as high/low performers, indicates conflict & cliques, etc. Should such issues be flagged for a student, faculty will step in and work with the student or team to solve or improve the situation. In addition to the faculty report, the CATME survey immediately sends an analysis to each student of their teaming review with suggestions for their improved performance. Since this is an early teaming experience, it should greatly assist students to become productive engineers when they graduate. The CATME process will continue to be evaluated by faculty and students in future semesters to see if any negative unintended consequences develop.

Since the project has multi- disciplinary facets, requirements for the Final Design Report are being evaluated for further improvement. The most recent advancement requires sections of the report to cover each major engineering area that the design includes- mechanical, electrical and computer aspects. It is hoped that this will increase involvement by all team members and increase awareness of the contributions of all members.

Figure 4-14 - Outcome d) Assessment Using EE264 Teaming Component

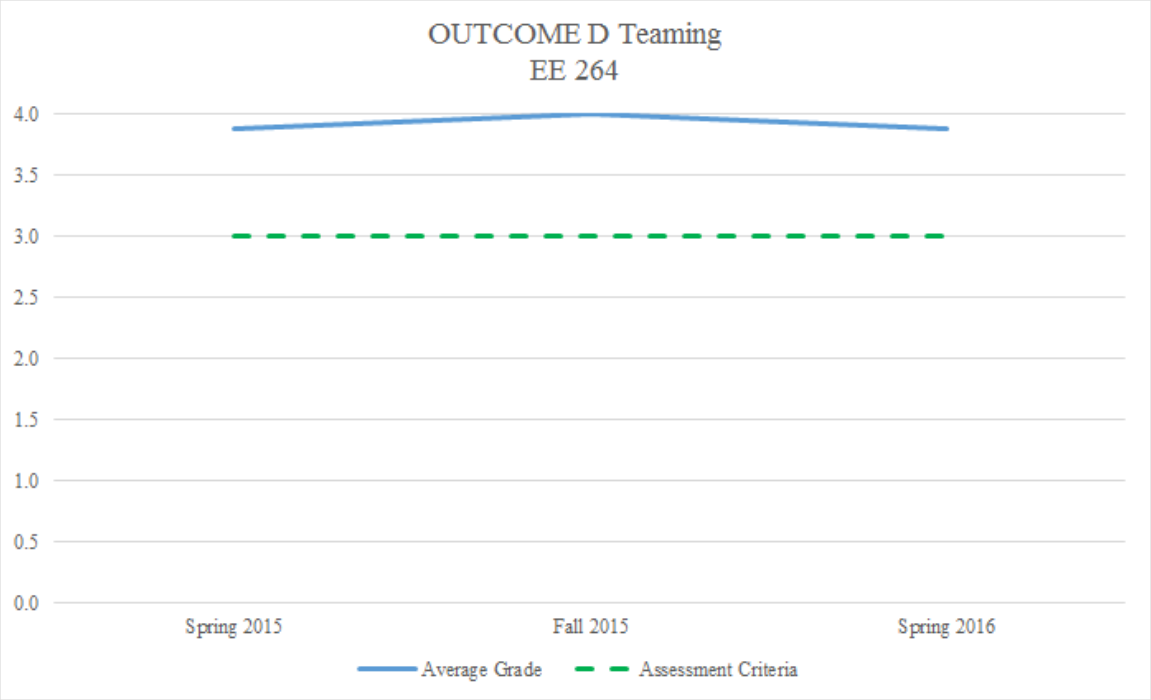
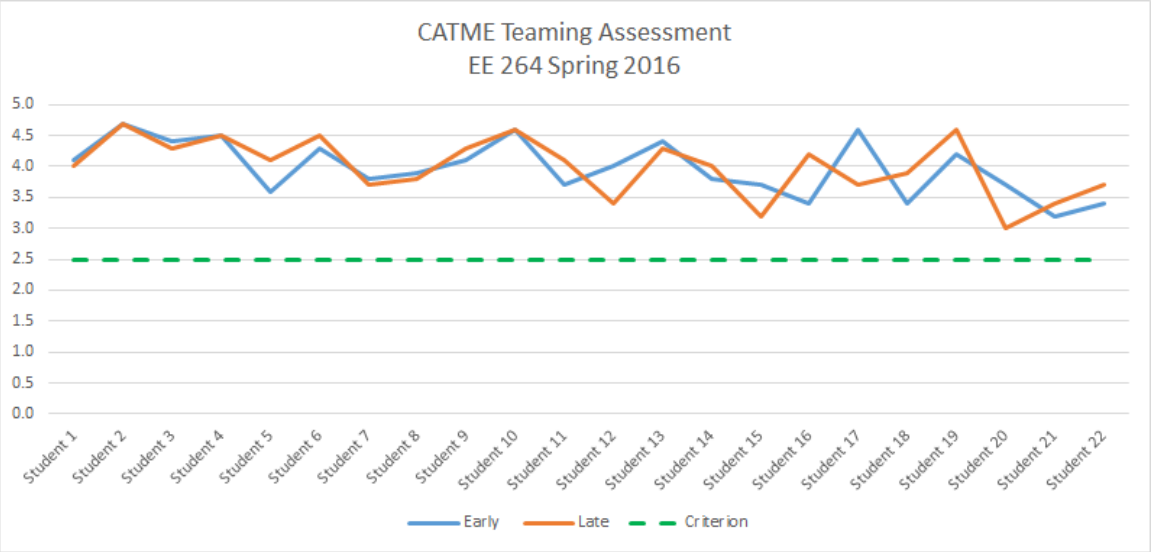


Table 4-10 - Representative Teaming Data from CATME Tool

CATME Teaming Assessment No 2								
CENG 264							Sem/Yr:	S 16
						Peer Assessment :		1
Student	CENG/EE	Team ID	Contrib. to Team	Interact w/ Team	Keeping on Track	Expect Quality	Having KSAs	Teaming Avg.
Student 1	EE	1	4.2	4.2	3.8	3.8	4.2	4.0
Student 2	EE	10	4.8	4.8	4.5	4.5	5.0	4.7
Student 3	EE	10	4.0	4.5	4.0	4.5	4.5	4.3
Student 4	EE	11	4.7	4.3	5.0	4.7	4.0	4.5
Student 5	EE	12	3.8	4.2	4.2	4.0	4.2	4.1
Student 6	EE	12	4.5	4.5	4.5	4.2	4.8	4.5
Student 7	EE	13	4.0	3.5	3.5	3.5	3.8	3.7
Student 8	EE	13	3.8	3.8	3.8	3.8	3.8	3.8
Student 9	EE	14	4.0	4.5	4.5	4.5	4.0	4.3
Student 10	EE	14	4.2	5.0	4.8	4.5	4.5	4.6
Student 11	EE	15	4.0	4.7	3.7	4.0	4.3	4.1
Student 12	EE	17	3.5	2.5	3.5	3.5	4.0	3.4
Student 13	EE	2	4.2	4.8	4.2	4.2	4.2	4.3
Student 14	EE	2	3.8	4.0	4.0	4.2	4.0	4.0
Student 15	EE	3	3.0	3.7	3.3	3.0	3.0	3.2
Student 16	EE	4	4.3	4.3	4.0	4.0	4.3	4.2
Student 17	EE	5	4.0	3.7	3.0	4.0	3.7	3.7
Student 18	EE	6	3.5	3.8	4.2	4.2	3.6	3.9
Student 19	EE	7	4.5	4.8	4.2	4.5	4.8	4.6
Student 20	EE	8	2.8	3.0	2.5	3.0	3.5	3.0
Student 21	EE	9	3.0	3.3	3.3	3.3	4.0	3.4
Student 22	EE	9	3.3	3.7	3.7	3.7	4.0	3.7

Figure 4-15 - Plot of Teaming Average Score from CATME Tool



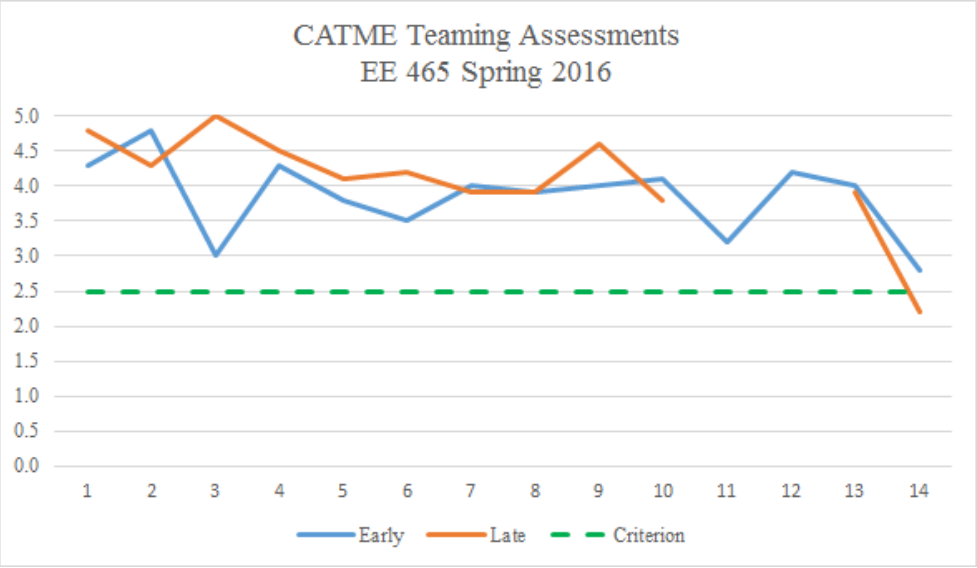
We see from the CATME data above that important team contributor skills are rated, including positive team interactions to maintaining schedule and quality performance. We note in the plotted data that most students improve during the course of the semester ("late" score > "early" score).

EE 464/465 is the CAPSTONE design and teaming experience for all EE graduates. Students select their own team and project, and work in conjunction with Mechanical Engineering and Computer Engineering seniors as dictated by the nature of the selected project. Prior to 2015, assessment of the teaming aspect of the project was primarily done through indirect assessment by peers, faculty, advisors and sponsors.

In 2015, we began using the CATME (Comprehensive Assessment of Team Member Effectiveness) Tool. Several times during the semester, the students perform peer assessments of themselves and the rest of their team using a CATME survey developed by the course instructors. These metrics are used as assessments as well as to help faculty monitor how the senior design teams are functioning. The survey flags both potential problems and successes in the teams. If problems exist, faculty can work with the team members to address and correct any issues that have developed. The teaming metric has been assigned a fairly high evaluation criterion. This has been done to reflect the student's general belief that they know how to be good team members. All CATME scores are examined by the course instructors for individual scores of 2.5 or less or averages less than a 3. Such scores trigger an intervention by instructors to correct any problem that has arisen in a team. This process should prove particularly helpful since Senior Design is actually a 2 semester course. Problems can be discovered and addressed during the first semester EE 464 course which should help the final experience be a positive one. The CATME process also provides direct feedback to each student, thus letting them know how their teaming efforts are being perceived.

Since the success of a team also reflects upon the final grade given to each student, direct assessment of the final grades has been tabulated and tracked.

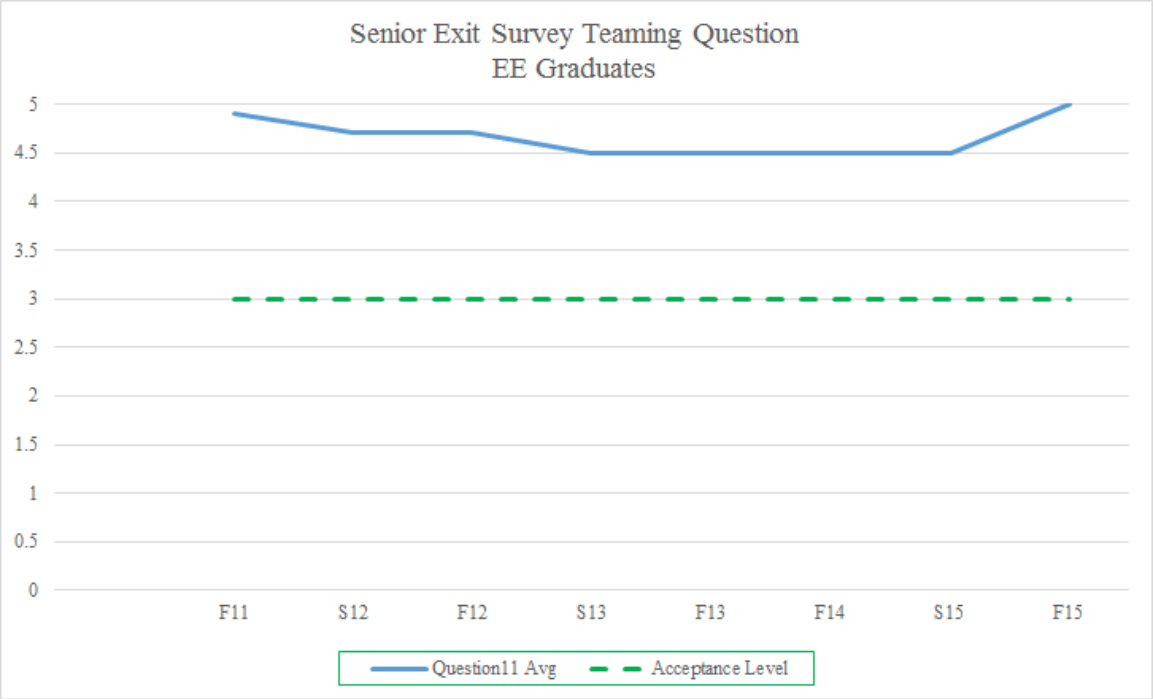
Figure 4-16 - Plot of Teaming Average Score from CATME Tool from EE465



In the above chart from EE465, student 14 showed lack of effort and was flagged as a low performer. Feedback was given through the CATME automatic reporting process.

The senior exit survey question which pertains to students' opportunities to work on a team are summarized across the 2011-2016 time period. Students rate this opportunity as occurring continuously throughout their time at SD Mines.

Figure 4-17 - Indirect Assessment of Teaming from Senior Exit Survey



Question 11 of the senior exit survey is: "I was given the opportunity to work and function in a group environment."

From the direct and indirect assessments summarized in this section, our students have numerous opportunities to work in a teaming environment with other disciplines. Students are provided feedback on their performance. We determine from this data that outcome d) is assessed adequately and successfully met.

5. Outcome e) - Engineering Problems

For outcome e), we selected direct assessments from two required courses and the FE exam. To augment the direct assessments, we used an indirect assessment from our senior exit survey, as shown in Table 4-8 below.

Table 4-11 - Outcome e) Assessment Tools & Criteria

Assessment Method	Performance Criteria	Source	Acceptance Criteria
Direct Assessments -	Eleven Homework Assignments	EE 381	rubric score>=2.0
course based assessments	Exams	EE 381	rubric score>=2.0
	Average Lab Grade	EE 382	rubric score>=2.0
	Circuit Analysis, Electronics, Power, Digital Systems	FE Exam	ratio score>=1.0
Indirect Assessments	Question 8	Senior Exit	score>=3.0
constituent surveys			

We selected student performance from EE 381 (Electric & Magnetic Fields) and EE 382 (Applied Electromagnetics) to assess outcome e). Both are required junior courses for EEs. These course have a significant mathematics and physical science content. Electric fields naturally complement the study of capacitors that the students are familiar with by this time. Magnetic fields naturally complement the study of inductors. Magnetic field concepts are used in EE330 Energy Systems (rotating machinery, transformers and basic power systems) which is also required for EEs in the junior year.

Transmission line and antenna problems are given throughout both courses in homework, exams and laboratory exercises. While the subject is a difficult one (Maxwell's equations, etc.) it has very practical applications for engineering designs (EMC / RFI issues) and is used to troubleshoot antennas / microwave systems, etc. We use homework and exam grades for EE 381, and lab grades for EE 382.

Figure 4-18 - EE381 Homework Grades

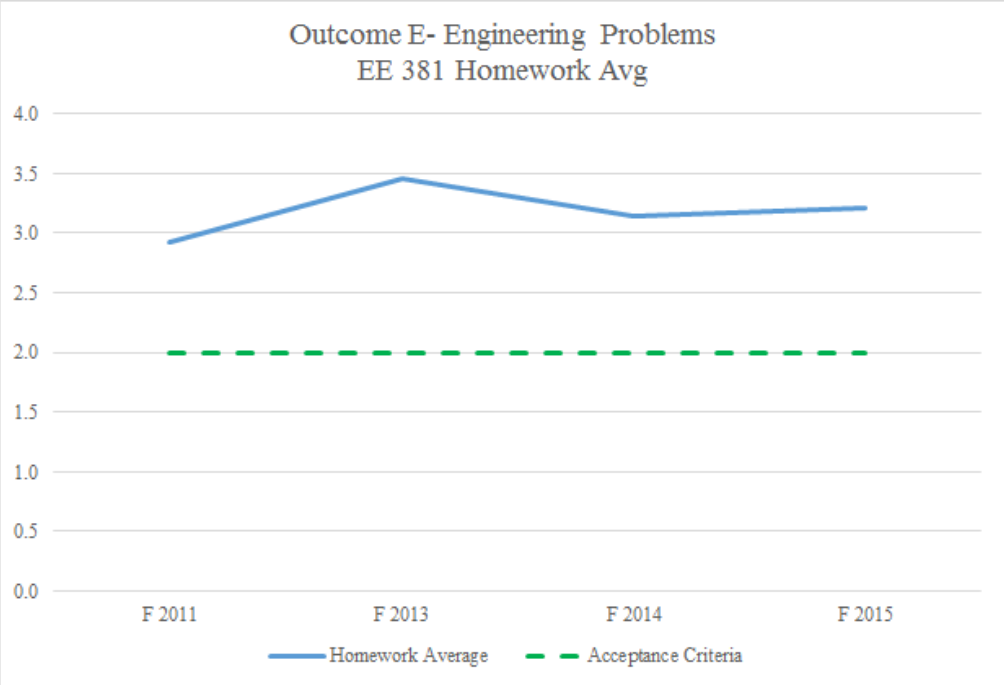
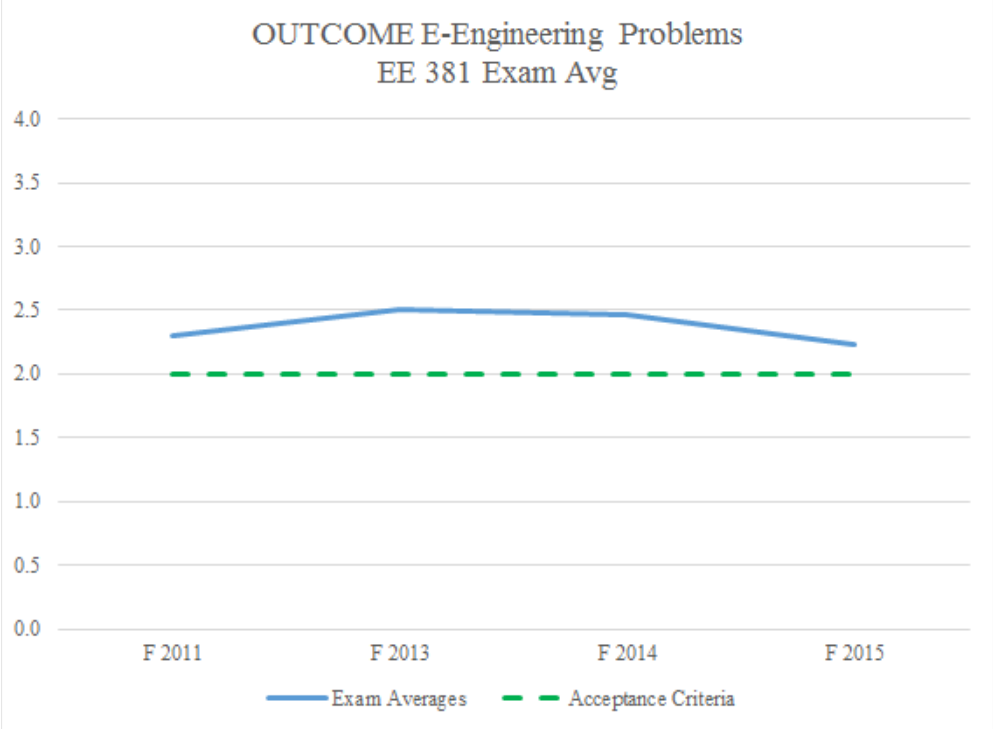


Figure 4-19 - EE381 Exam Grades



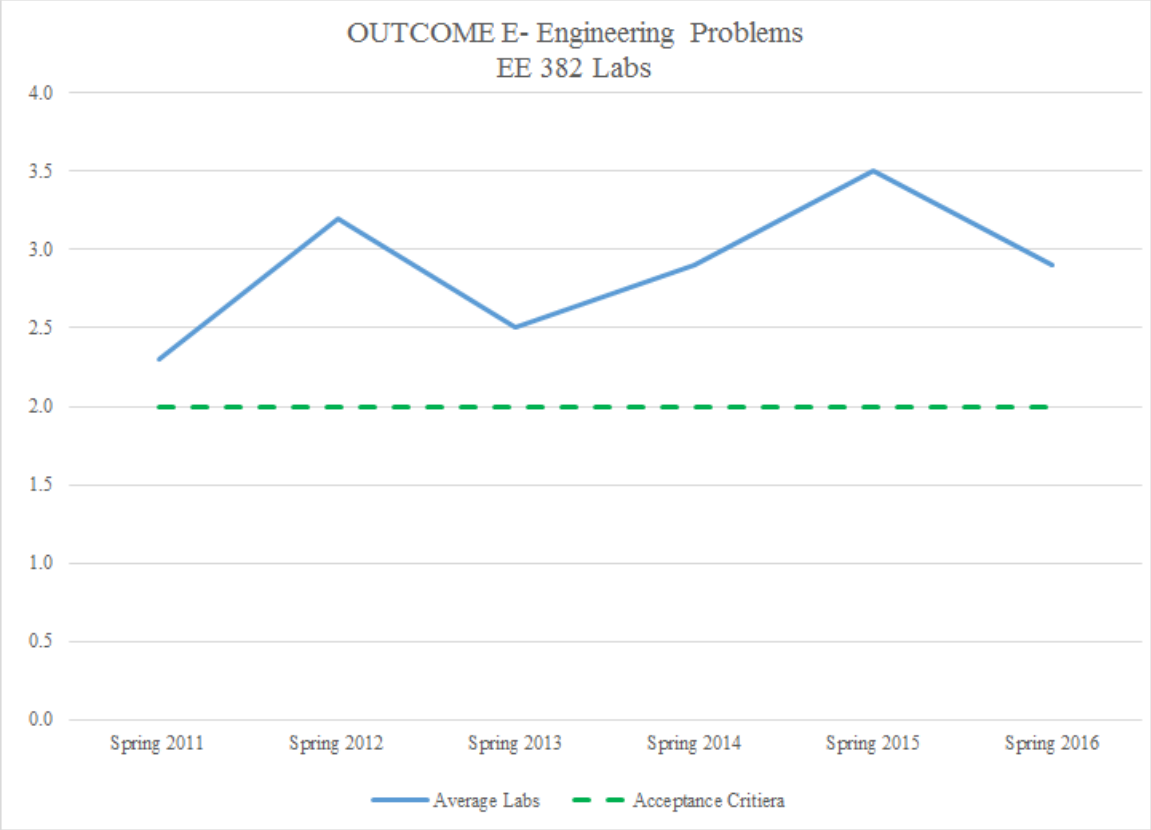
EE 381 assessment for outcome e) is based on both the homework assignments and exams. Each item occurs after the same material is covered in the course. The questions are not exactly the same from year to year to eliminate students from passing down the homework to the next years students. However, the same material is evaluated in each of the homework assignments and exams.

Students are generally weak on vector calculus. Also pacing of the course is critical and magnetostatics is usually covered only in a cursory manner. Additional example problems were added in certain areas to help students (boundary condition sample problems and problems on Ampere's Law).

Over the years, the instructor has added to the number of quizzes which seems to focus students staying up to date with the course. The students don't generally have the math background to grasp electromagnetic analysis concepts deeply.

The lab grades from EE382 (Fields 2) are also used to assess outcome e), and are shown below.

Figure 4-20 - EE382 Lab Grades



An average of 2.0 or greater is selected for this assessment. This reflects the requirements for a 2.0 (C grade) or better to pass.

The Circuit Analysis, Electronics, Power, and Digital Systems sections of the FE exam were also used to assess outcome e). We used a 1 ratio as the proficiency score and a .9 triggers a concern if it occurs 2 sessions in a row.

Figure 4-21 - Circuit Analysis Section of FE Exam

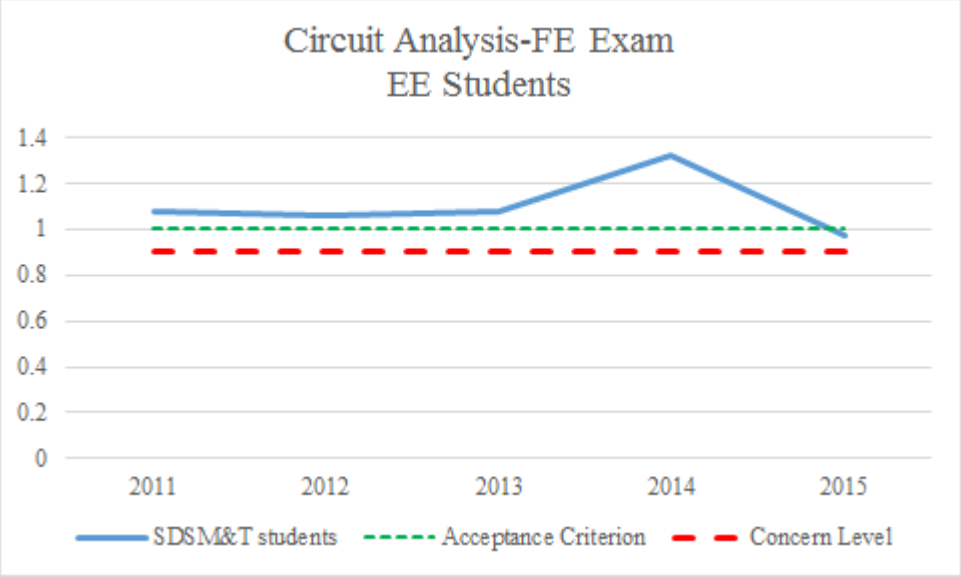


Figure 4-22 - Electronics Section of FE Exam

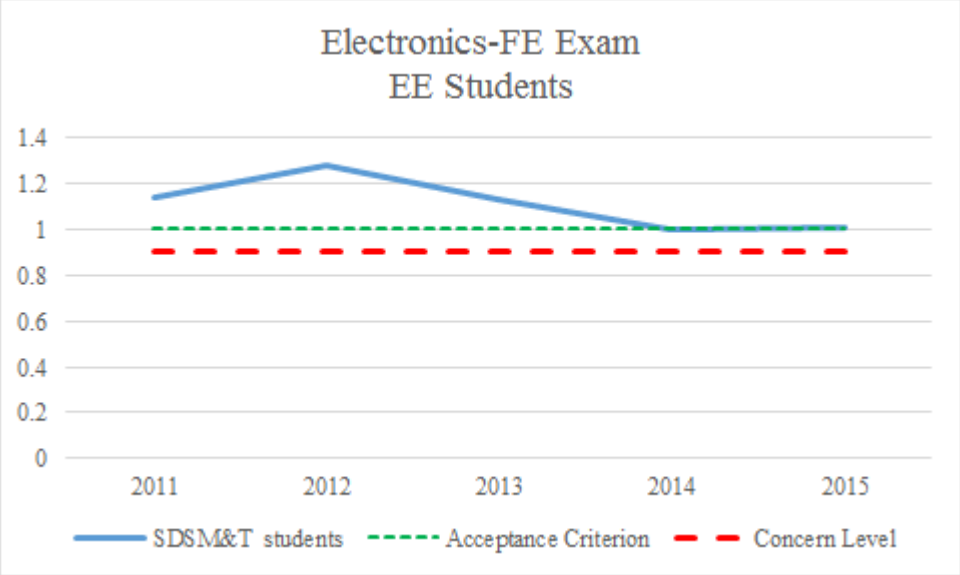


Figure 4-23 - Power Section of FE Exam

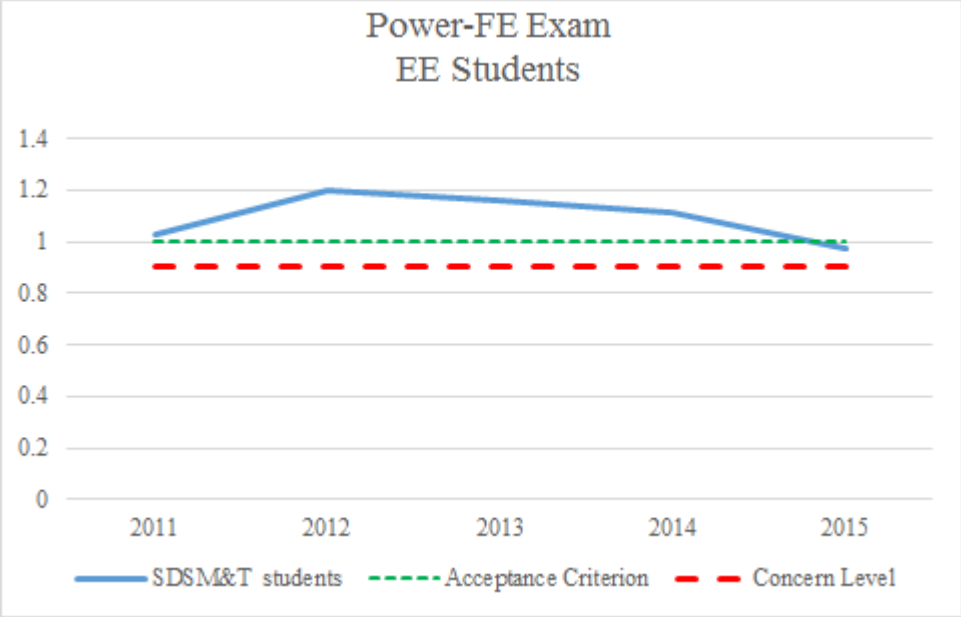
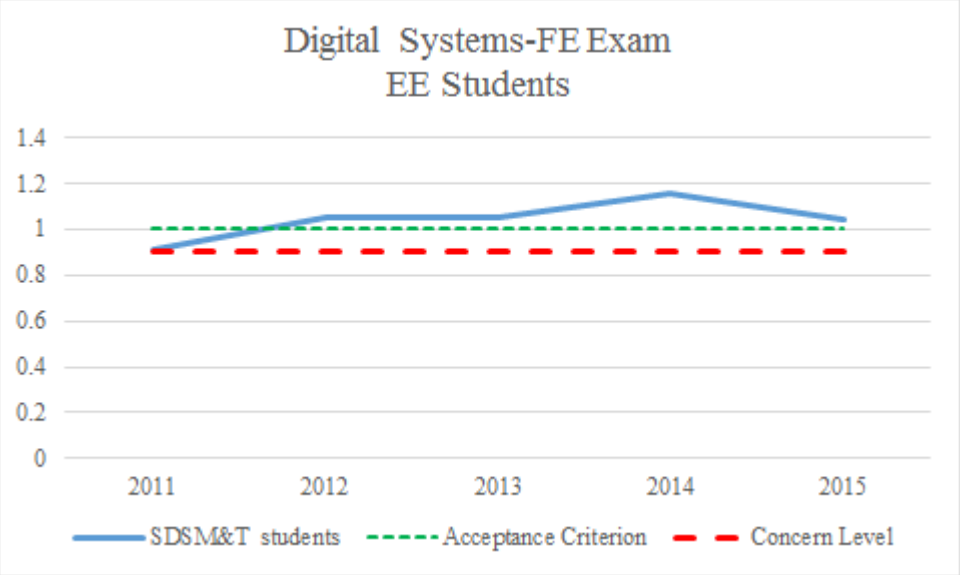


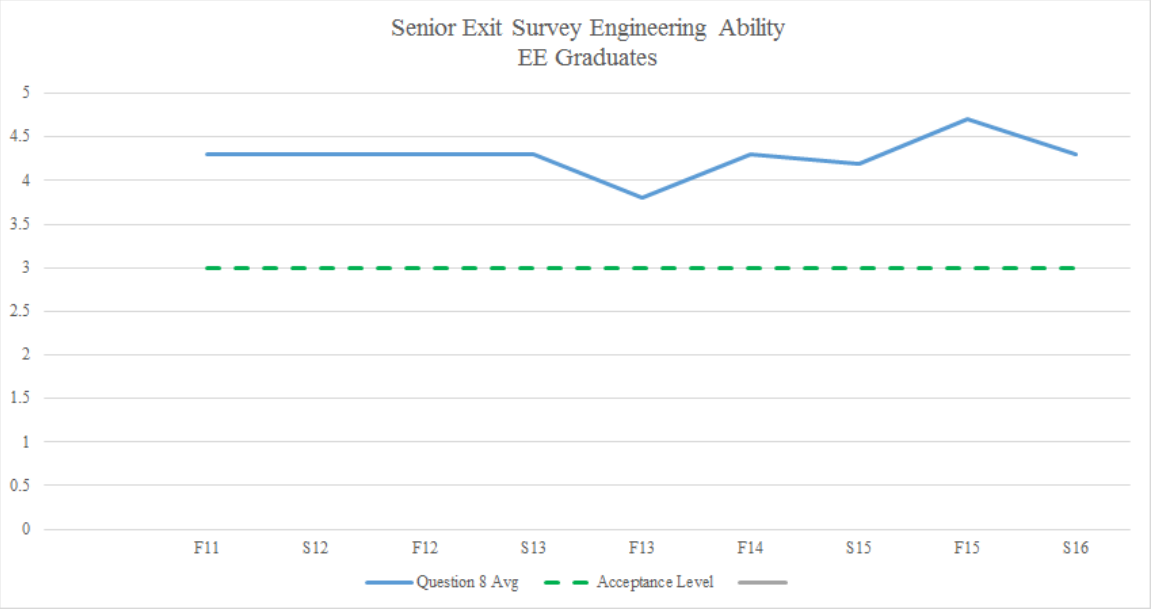
Figure 4-24 - Digital Systems Section of FE Exam



There were no real concerns although 2015 seemed to be a little lower than normal in the Circuit Analysis and Power scores. Both will be watched in the future to see if the downward trend continues or is just an anomaly.

An indirect assessment, question 8 from our senior exit survey, was also used to supplement our assessment of outcome e).

Figure 4-25 - Senior Exit Survey Results for "Engineering Ability"



Indirect assessment from the senior exit survey indicates that the students feel prepared start their engineering careers.

6. Outcome f) - Ethics

We assess outcome f) with three direct assessments (ethics quiz, essay and FE exam results) and with one indirect assessment (senior exit survey), as shown in the table below:

Table 4-12 - Outcome f) - Ethics Assessment Methods

Assessment Method	Performance Criteria	Source	Acceptance Criteria
Direct Assessments	ethics quiz	EE 220	rubric score>=2.0
course based assessments	VW cheating essay	EE/CENG 351	rubric score>=2.0
	Ethics and Business Practices	FE Exam	Ratio Score>=1.0
Indirect Assessments	Question 6	Senior Exit	score>=3.0
Constituent Surveys	Question 20	Senior Exit	rubric score>=2.0 (Proficiency)
	Question 21	Senior Exit	rubric score>=2.0 (Proficiency)

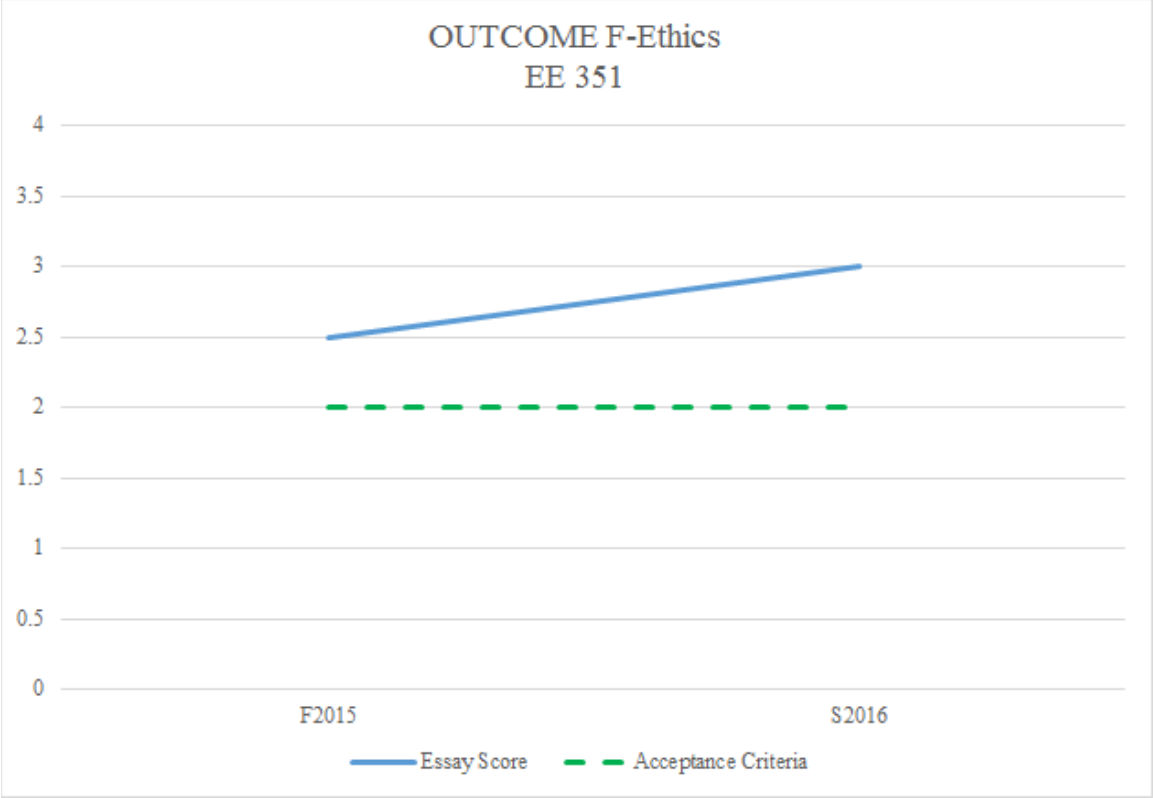
EE220 (Circuits 1) is the first fundamental course for all EE majors. It is taken during their sophomore year and begins their study of electronics and electric circuits. The course has always been initiated with a presentation on ethics / cheating / proper laboratory documentation, etc. In the last two semesters, this has been formalized as part of the lab process / course introduction. A quiz over the IEEE code of ethics and some practical ethical consideration has been implemented as a device for capturing metrics.

Figure 4-26 - EE220 (Circuits 1) Ethics Quiz

A rise in the EE220 rubric scores has been seen as a more formalized presentation has been included.

Ethics is once again examined with an essay assignment covering the recent VW emissions scandal. This is a new assessment which was initiated in EE351 (Mechatronics) in 2015. Since the topic was prominent in the news media, we took advantage of it and included it in this required course.

Figure 4-27 - EE351 (Mechatronics) Ethics Essay Results

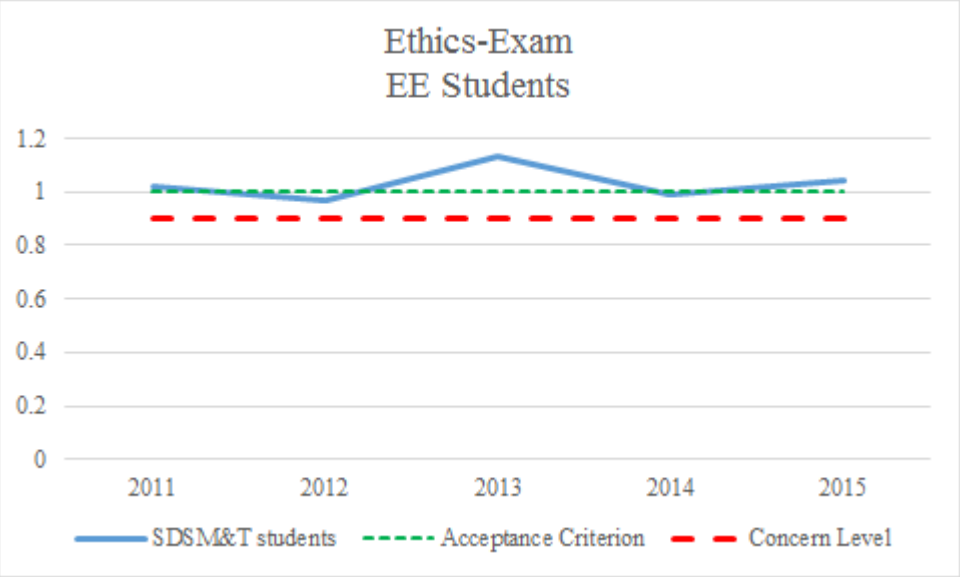


This has actually proven quite beneficial to the students. Their concluding statements indicate a dawning realization that ethical conduct may be difficult to maintain if the company itself does not balance profit vs. ethics.

Additional ethical instruction is given throughout the curriculum during the introduction to each course and discussions of cheating, how to complete your homework (copy or community efforts), lab book standards and why they are necessary. Samples of instructional handouts from EE 264 sophomore design and EE 464 lesson on the Union Carbide / Bhopal India incident are included in the course outcome binder for Ethics.

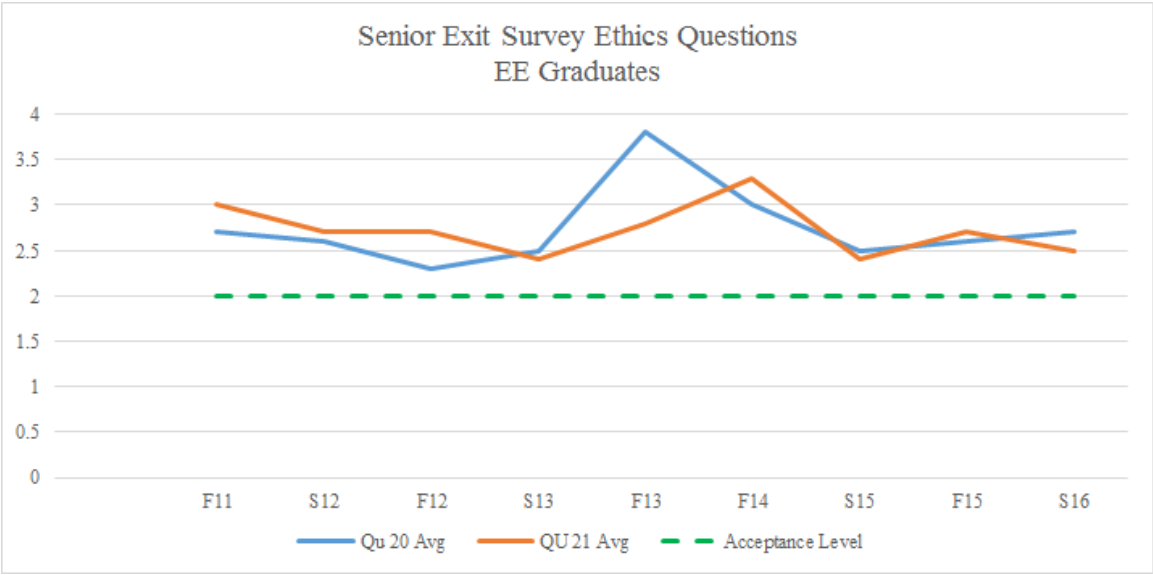
In addition, examination of the FE Exam scores on “ethics and Business Practices” has been done. It shows the scores since 2011 and uses the ratio method to represent SD Mines students vs. national scores. A desired proficiency has been set as a 1.0 with concern and action being taken if consecutive scores fall below .9.

Figure 4-28 - FE Exam Results - Ethics Section



An indirect assessment of this outcome is also done with graduating seniors during their exit interview. An assessment criteria of 3 in a 1 to 5 scale has been set. Students are also given two written questions on ethical codes during their survey. A rubric was used to score the survey questions, with results shown below

Figure 4-29 - Senior Exit Survey - Ethics



Satisfactory scores have resulted for this assessment. SD Mines students feel that they are well prepared to face ethical considerations upon graduation.

Based upon the data in this section, we determine that outcome f) is assessed adequately and that we meet the requirement to have our graduates be cognizant of ethical issues in their jobs.

7. Outcome g) - Communications

Focused education in communication skills is covered by required courses in ENGL279 (Composition) and ENGL 289 (Technical Communications). A total of 15 credit hours of English communication related courses are required as represented in the curriculum as SD Board of Regents Goal #1 and Goal #2.

The CAAP exam evaluates each student's writing skills and must be passed satisfactorily to allow the student to continue their studies past their sophomore years.

We us direct assessments from our EE320 (Electronics 1), EE464 (Senior Design 1) and EE465 (Senior Design 2). We supplement this data with indirect assessments from EE464 (Senior Design 1), EE465 (Senior Design 2) and our senior exit surveys as shown in the table below:

Throughout all ECE courses, faculty remain aware of each student's communication skills. Interventions are begun if necessary. Such actions have included adjustments for student's with learning challenges to refusal to grade messy or poorly written work. For ABET assessment, two courses have been selected within the ECE programs to further evaluate students communication proficiencies as related directly to their majors.

Table 4-13 - Outcome g) - Communications Assessment Methods

Assessment Method	Performance Criteria	Course	Acceptance Criteria
Direct Assessments	Laboratory Notebook rubric	EE320	Score of 2.0 out of 4 , meaning marginal communcation skills were observed
Course based assessments	Oral Poster presentation	EE/CENG 464 & 465	Score of 3.0 out of 4, meaning communication skills were proficient
	Written final design research paper	EE/CENG 465	Score of 3.0 out of 4, meaning communication skills were proficient
Indirect Assessments	Preliminary Design Review Presentation	EE/CENG 464	Score of 2.5 out of 4 , meaning developing communcation skills were observed
Constituent Assessments-peers, public, sponsors, faculty	Critical Design Review Presentation	EE/CENG 464	Score of 3.0 out of 4, meaning communication skills were proficient
	Design Fair Poster Presentation	EE/CENG 464	Score of 3.0 out of 4, meaning communication skills were proficient
Senior Surveys	Question 9	Senior Exit	Sore>=3.0
	Question 10	Senior Exit	Sore>=3.0
		Alumni	
		Employer	
		IAB Board	

EE320 (Electronics 1) is required for EE majors and is normally taken during the student's junior year. At this point the student has taken the required English Composition course and has had several laboratory classes requiring lab books and lab reports, and has had Sophomore design. As a result, the student should be becoming quite proficient at preparing written laboratory reports. A standard part of the lab grading system has included points for professional and legible reports. Samples of this are included in the outcome g) binder. In an effort to numerically assess written communication, a rubric has been developed which will directly assess the student's communication skills in EE320. It is done by the course instructor twice during each semester. This assessment is returned to the individual student to provide feedback and motivation for subsequent improvement. Results are shown in the following table:

Table 4-14 - Communication Assessment in EE320 (Electronics 1)

Rubric for Performance Indicators Of Abet Outcome (g)

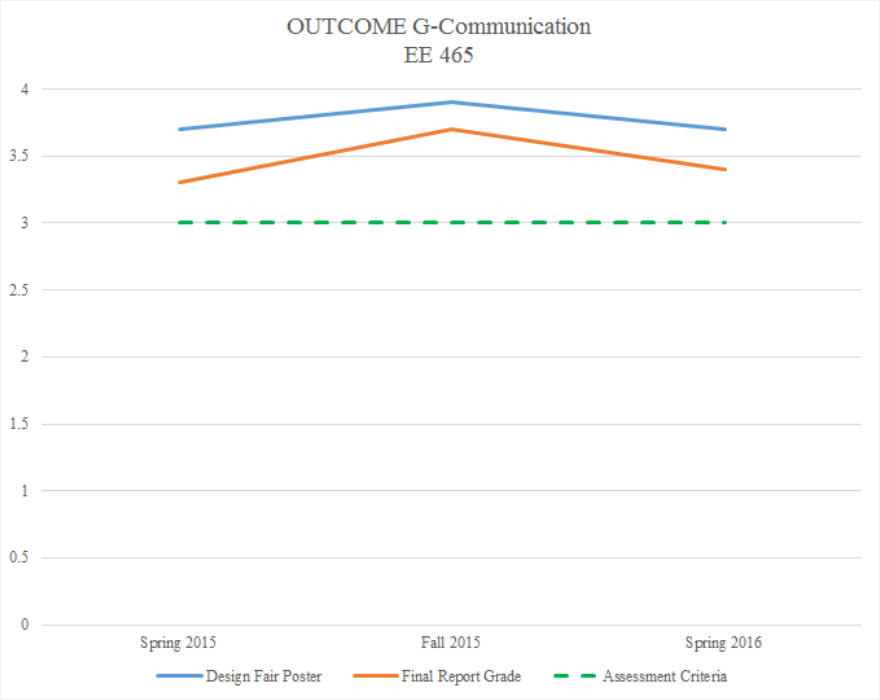
An ability to communicate effectively -- Written Communication (Laboratory Documentation)

Performance Indicator	1: Unacceptable	2: Marginal	3: Acceptable	4: Exceptional	Points	Average
Organization of the laboratory notebook is consistent with specified standards Weight=2	Little organization making the document hard to follow. Purpose of lab is not clearly stated. Missing observations or conclusion of lab. **# of students: 0**	Confusing organization . Purpose of lab is stated but does not aid in understanding the overall lab. Weak observations or conclusion. **# of students: 6**	Information is generally organized in a logical format which can be followed easily. Purpose and conclusion of the lab are clearly stated. **# of students: 15**	Organization is done in an effective manner which would allow duplication of the experiment to be accomplished. Well-stated purpose of lab and strong conclusion are presented. **# of students: 11**	101	3.16
Content of the laboratory notebook is of sufficient depth to be effective to the intended audience. Weight=3	Lab documentation does not complete the stated purpose. Reiteration of the assigned task with incomplete Pre-Lab Assignment Section. No conclusion/ ideas/ interpretations or answered questions presented. **# of students: 0**	lab generally completes its purpose in a superficial manner. Basic concepts and knowledge are demonstrated in the Pre-Lab Assignment Section. Some ideas/ analysis/interpretations are presented in a shallow manner. **# of students: 6**	Lab documentation fulfills its intended requirements in a logical manner appropriate to its intended audience. Good understanding of required concepts and knowledge required as evidenced in written document. Ideas/conclusion are presented well thought out showing some breadth of knowledge and analysis. **# of students: 13**	Well presented laboratory notebook showing demonstration of broad knowledge of subject, detailed analysis of all information and well supported conclusions/ideas. **# of students: 13**	93	2.91
Visual Presentation of the laboratory notebook enhances the audience understanding of the lab. Weight=1	The lab write-up does not use a consistent logical format of data in either style, location or numbering within the document. Rare use of figures, tables, oscilloscope pictures and graphs to present information concisely. **# of students: 1**	Information uses a fairly consistent format of all required data and is generally legible. Insufficient use of figures, tables, etc. to present information in a concise/non-text format. **# of students: 6**	Format of information is generally consistent with good ratio of information to visual legibility maintained. Sufficient use of figures, tables and illustrations to properly present material. **# of students: 15**	Format of information is consistent throughout and aids in understanding document. All figures, tables and illustrations have been chosen to use the proper method (graph type/table format) to logically display the information. **# of students: 10**	98	3.06
Grammar and syntax in the written document demonstrate proper usage. Weight=1	Numerous grammatical, punctuation or spelling errors are present. Sentence structure is often awkward. No proofreading appears to have been done. **# of students: 0**	Several grammatical, punctuation or spelling errors exist. Sentence structure is occasionally awkward. Limited or hasty proofreading appears to have been done. **# of students: 10**	Minor grammatical, punctuation or spelling error exist. Sentence structure well crafted to assist with audience understanding. Proofreading appears to have been done but additional revision could improve overall understandability. **# of students: 11**	Negligible grammatical, punctuation or spelling errors exist. Sentence structure well crafted to assist with audience understanding. Thorough proofreading and revision appear to have been done. **# of students: 11**	97	3.03
Total Points (with weight)					676	3.02

Communication occurs throughout the Senior Design experience. It takes such forms as written weekly progress reports, weekly status meetings with faculty, mentors and sponsors as well as the formal preliminary design report (a written and oral presentation), Design Fair Poster and Presentation, a Critical Design Report (written and oral presentation) and the final design report and user's manual. Written communication is included as a part of the final design project report grade. An oral Design Poster presentation grade is also included in the course grading system.

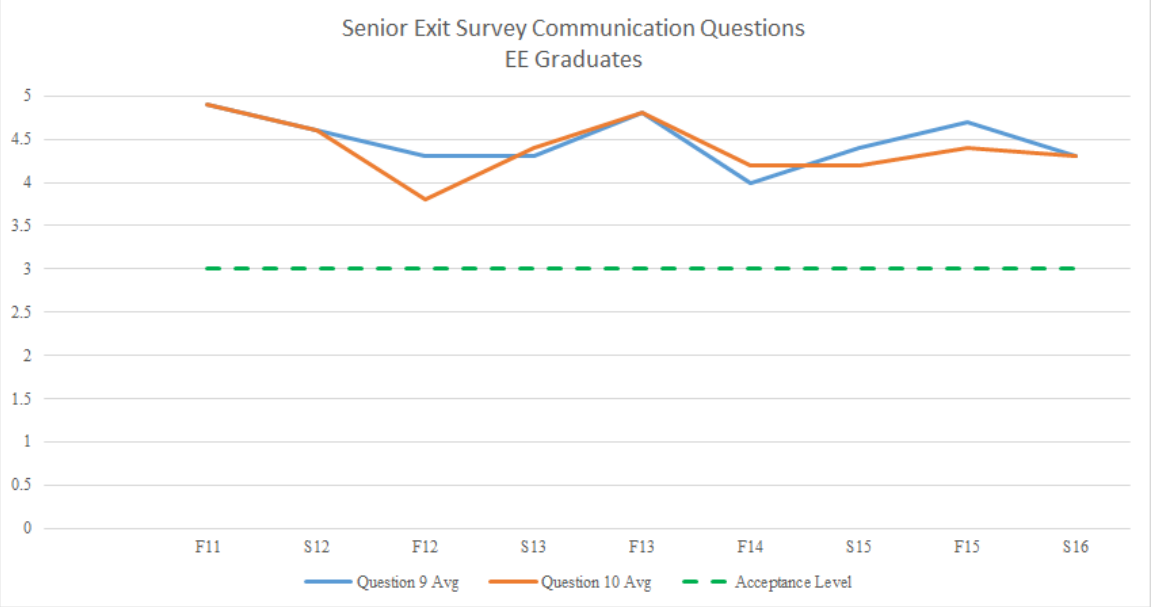
In addition to using the final grades from Senior Design 1 and 2, rubrics were created in 2015 to evaluate the three main Senior Design presentations- PDR, CDR, and Design Poster. When each event takes place, audience members are asked to complete a Communication Rubric for each team and its members. The rubrics are tabulated for assessment purposes but also are given back to the teams as a method of immediate evaluation and critique. Since the audience is a composite of faculty, course instructors, sponsors and peers, low scores serve as a flag for individual teams and their members that they are having a problem with their communication skills. Proficiency scores of 2.5 (75%), 3.0 (80%) and 3.0 (80%) for the PDR, CDR and Design Poster respectively have been set and are being met in the time since the rubrics have been tracked. A distinct improvement in oral communication skills is observed during the Design Fair presentations. This event occurs within the last 2 weeks of the graduating seniors' semester.

Figure 4-30 - Result of Communication Component of Senior Design Course



An indirect assessment of exiting seniors occurs during their exit survey process. Each senior rates their perceived competency in both oral and written communication. Exit survey question #9 "I feel competent regarding written communication skills. Score from 1 to 5 (5 being highest)". and questions #10 "I feel competent regarding oral communication skills. Score from 1 to 5 (5 being highest)". An acceptance criteria of 3 in a 1 to 5 scale has been set.

Figure 4-31 - Result of Communication Component of Senior Exit Survey



Satisfactory scores have resulted for this assessment.

Using the results of our EE curriculum assessment, which also reflect 15 hours of communication courses from the Humanities Department, we determine that our outcome g) is assessed adequately and that outcome g) is met.

8. Outcome h) - Global & Society

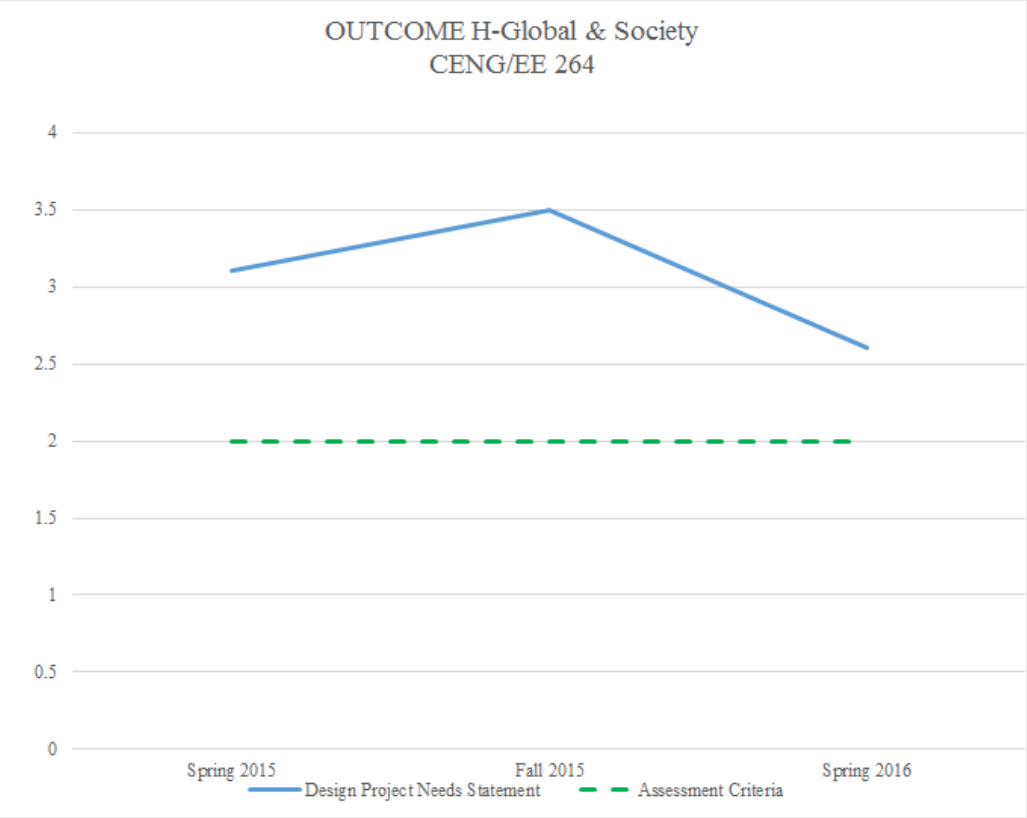
Global and societal impacts of engineering are primarily discussed in the design and teaming courses---EE264 (Sophomore Design), EE351 (Mechatronics), EE 464 / 465 (Senior Design 1 & 2). The Sophomore and Senior Design courses will be the highlighted courses for direct assessment of outcome h). Indirect assessment using our senior exit survey will supplement the direct assessments from the courses.

Table 4-15 - Assessment of Outcome h) - Global & Societal Impact

Assessment Method	Performance Criteria	Course	Acceptance Criteria
Direct Assessments	Project Needs Statement	EE/CENG 264	rubric score>=2.0
Course based assessments	Bhopal Essay	EE/CENG 464	rubric score>=2.5
	STEM Essay	EE/CENG 464	rubric score>=2.5
Indirect Assessments	Question 32	Senior Exit	rubric score>=2.5
Constituent Surveys			

EE264 (Sophomore Design) is the initial design course for EE students. They receive a series of lectures on the design process including the topics creativity, economics, societal impacts and global effects. Those slides have been included in the outcome binders. In addition, one of the first assignments for each team of students is to create a needs statement that should cover their project's societal value, technological challenges / needs and the economic requirements for such a product. A rubric to assess these needs statements has been created and utilized. This course is taught by both ECE and ME department faculty.

Figure 4-32 - EE264 (Soph Design) Results Introduced in 2015



An average of 2 or greater for these tasks is selected to be the proficiency goal. This is the initial design engineering class for EE students and therefore they are just beginning to develop the necessary awareness of all engineering project impacts.

During the first semester of the Senior Design project experience, several short essay assignments are given and a rubric has been created to assess the essays. The essays cover the Union Carbide Bhopal India Disaster and a series of IEEE articles on the STEM job outlook. Rubrics, resulting assessments and samples of this analysis/essays are included in the outcome h) binder, with summary results shown below.

Figure 4-33 - EE464 (Sr Des) Bhopal Essay - Introduced in 2015

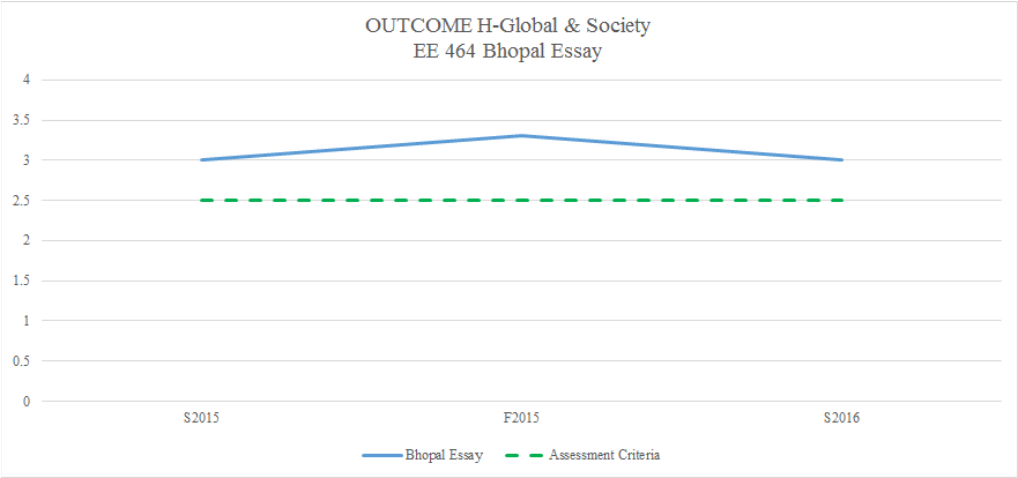
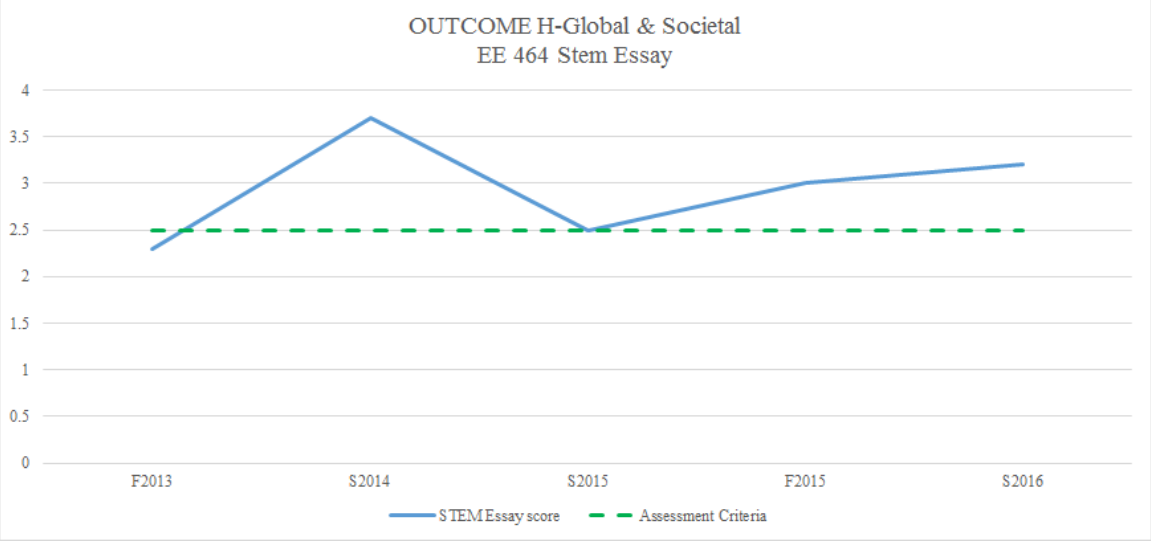
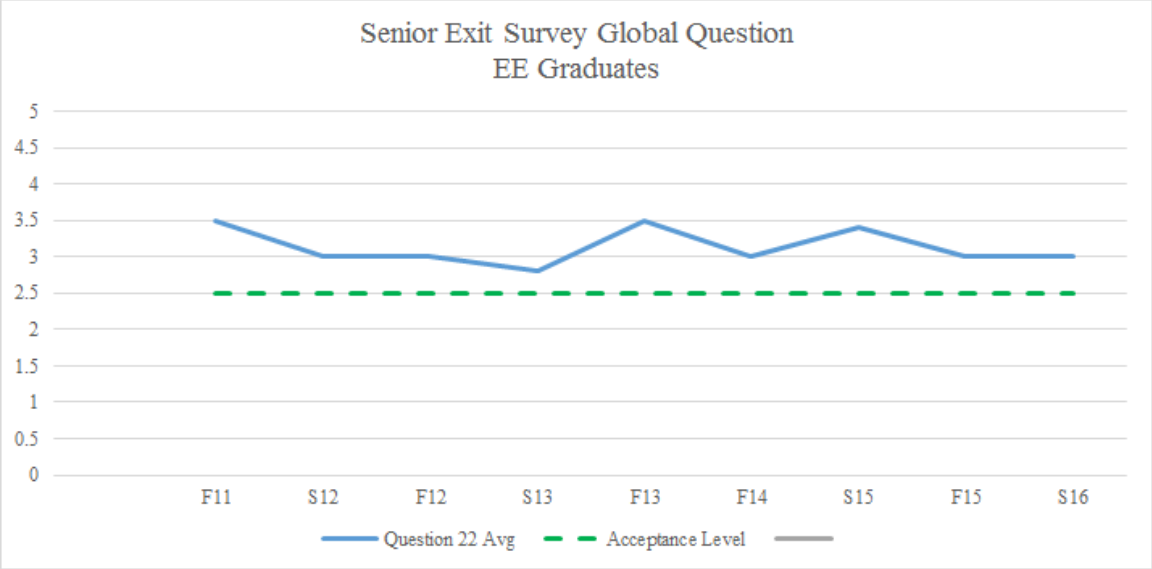


Figure 4-34 - EE464 (Sr Des) STEM Essay - Introduced in 2013



An indirect assessment of exiting seniors occurs during their exit survey process. One essay question is included which covers a global and societal engineering choice. A rubric to analyze those essays has been created and has been used for many years. An acceptance criteria of a 2.5 out of 4 has been set reflecting that graduating seniors should be able to thoughtfully answer the question with a justification of their answer.

Figure 4-35 - Global / Societal Impact Question from Sr. Exit Survey



Based on our direct and indirect assessments of outcome h), we determine that outcome h) is met, and that our students will be aware that their future design activities will be affected by global and societal considerations.

9. Outcome i) - Life Long Learning

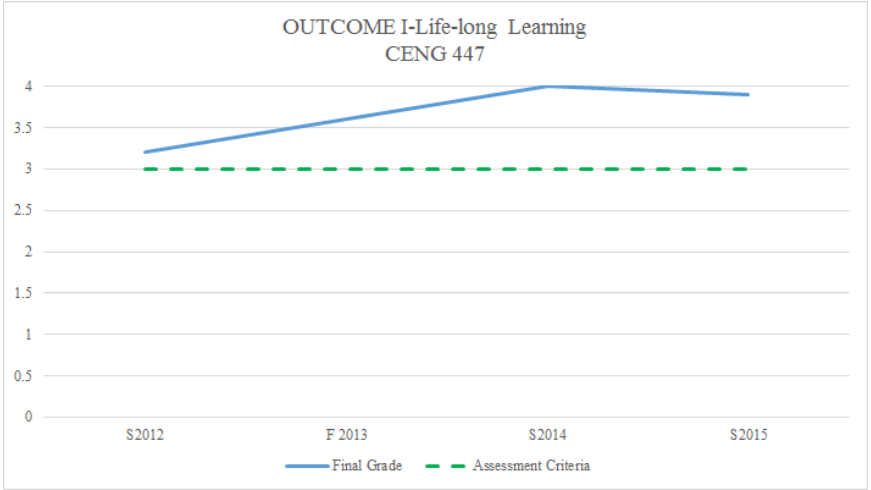
Various courses emphasize the ever changing nature of electrical engineering. Two courses have been selected for direct assessment. They are CENG 447 (Embedded systems) which is a required course in our Embedded Systems focus area for those seniors not electing to take ME211 (Thermodynamics). The second course to be examined is the first semester of the Capstone Senior Design process which is required for all EEs. Finally, questions from the senior exit survey are used to assess graduates recognition of the requirement to continue life-long learning.

Table 4-16 - Assessment of Outcome i) - Life Long Learning

Assessment Method	Performance Criteria	Source	Acceptance Criteria
Direct Assessment	Final Project	CENG 447	rubric score>=3.0
Course Based Assessments	Stem Essay	EE/CENG 464	rubruic score>=2.5
Indirect Assessment	Question 4	Senior Exit Survey	score>=3.0
Constituent Surveys	Question 5	Senior Exit Survey	score>=3.0
	Question 23	Senior Exit Survey	score>=2.5
	Question 24	Senior Exit Survey	score>=2.5

CENG 447 (Embedded Systems) covers such topics as code reuse and code documentation. In addition, the course outcome 9 states "use design resources such as professional journals, trade journals, data sheets, and the web in an embedded design." Samples of the final design project will be included in the outcome binder and assessment will performed by tracking the overall final grade.

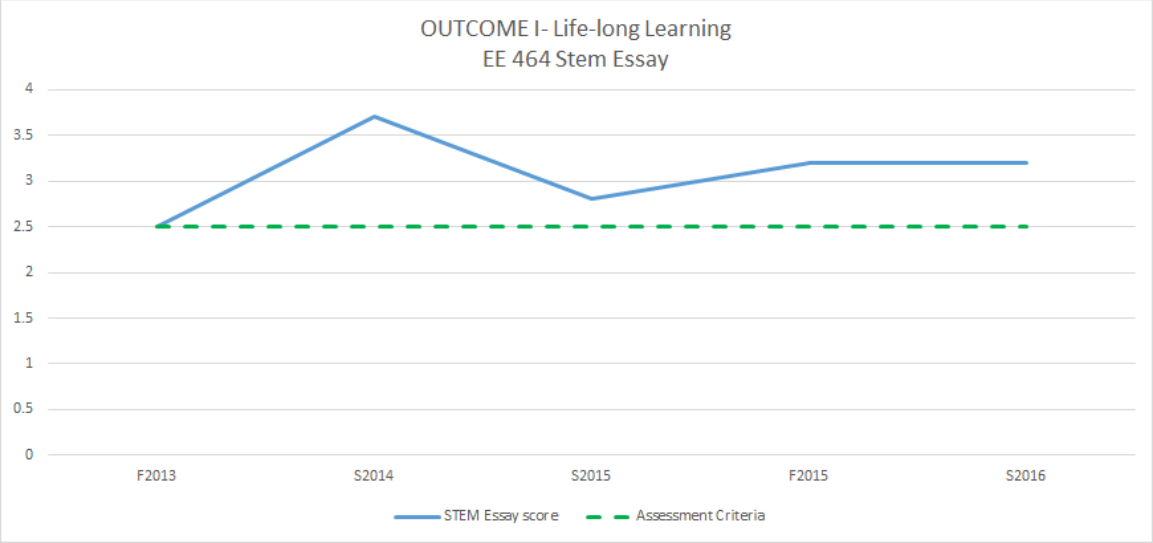
Figure 4-36 - Life Long Learning Data from CENG447 (Embedded Systems)



CENG 447 assessment for outcome i) is based on the final grade. This outcome is considered during the courses' fulfillment of course outcomes "8. Understand concepts of code reuse for future revisions, code documentation for colleagues, and professional/ethical development in the context of embedded system design" and "9. Use design resources such as professional journals, trade journals, data sheets, and the web in an embedded design." A complete design project manual is required as a deliverable of the final project. This aspect of the final project is one factor in the overall project grading process.

During the first semester of the Senior Design project experience, an essay assignment consisting of a review and analysis of a series of IEEE articles on STEM occupations is assigned. A rubric has been created to analyze these essays in accordance with outcome i) and the assignment parameters. Rubrics, course scorings and samples of this analysis are included in the outcome i) binder.

Figure 4-37 - Life Long Learning Data from EE464 (Sr Des) Stem Essay



An indirect assessment of life-long learning occurs during the senior exit survey process. This is accomplished during the survey's program achievement section by two specific life-long learning questions. The student responses are tabulated and tracked in this outcome binder under the "OTHER ASSESSMENTS" section. A 3 out of possible 5 points has been set as the assessment criteria and has been consistently met. In addition two essay questions are included which cover how life-long learning could be accomplished after graduation and the benefits of pursuing a personal philosophy of lifelong learning. This survey data has been used to assess outcome i) for many years, but a new rubrics has been produced to more critically analyze the responses to these survey questions. An acceptance criteria of 2.5 out of 4 for the essay questions has been set reflecting that graduating seniors should be able to thoughtfully answer the questions and include samples or justification. The rubric is included in the outcome i) binder.

Figure 4-38 - Life Long Learning Questions #23 & 24 from Sr. Exit Survey

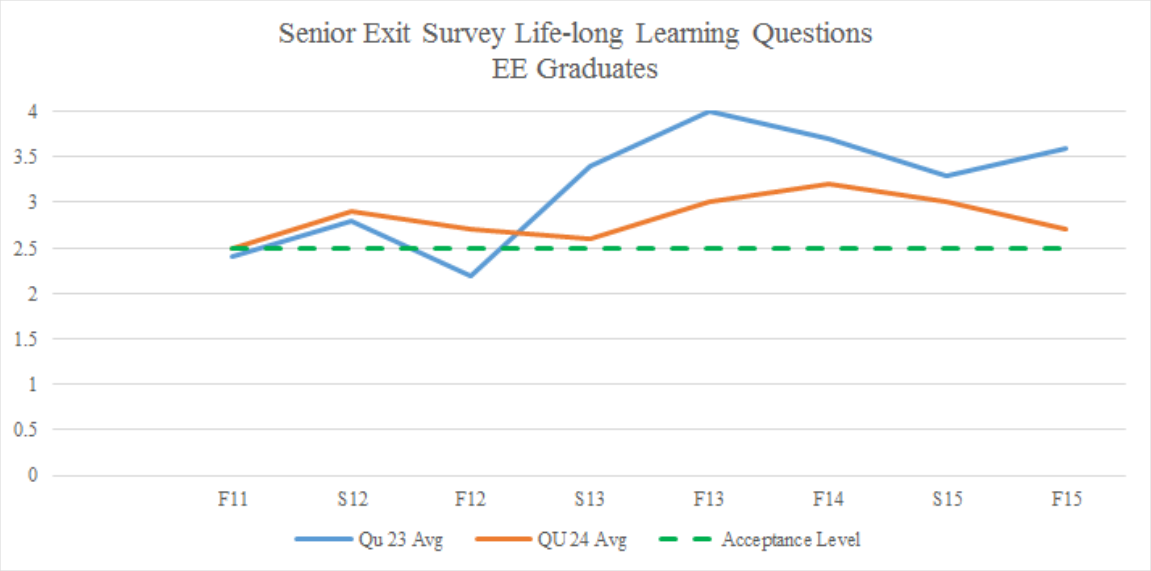
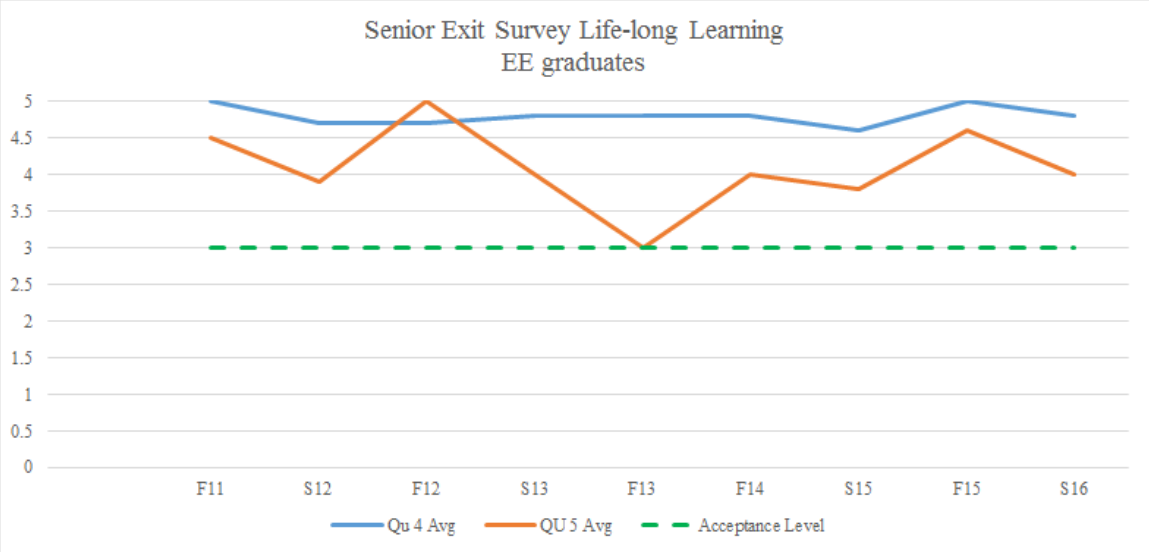


Figure 4-39 - Life Long Learning Questions #4 & 5 from Sr. Exit Survey



With one exception, satisfactory scores have resulted from this assessment.

Based on the direct assessments of course material, and supplemented with results of our indirect assessment, we determine that we meet outcome i) and that our students are aware of the need for lifelong learning during their professional life.

10. Outcome j) - Contemporary Issues

In the past we have used an alumni survey and information from our senior design courses to assess this outcome. We have added rigor to the assessment process by selecting two technical courses with direct assessments in addition to an indirect method relating to our senior exit survey. Two courses have chosen to assess this outcome.

EE 330 (Energy Systems) was selected because it is a required junior level course for all EEs and covers many issues related to energy production and use. An additional lecture was developed which focuses upon US and word wide energy production, and a rubric was used to evaluate an in-class exam covering the material.

CENG 447 (Embedded Systems) is a senior level course for CENG majors focusing on embedded design. Since this subject area affects all system - level applications today it also seemed the proper choice for assessment. An additional essay assignment was initiated covering "climate change". Students are tasked to not only present their personal stance on the issue, but to substantiate it with scientific articles to support their opinion, and to propose an engineering design to collate data or analyze data to support their position.

Finally, an assessment of the senior survey essay question 25 is done to assess the responses to 3 contemporary issues of importance and what engineering will contribute to a solution. A rubric assessment score of 2.5 was selected and is generally being met.

Table 4-17 - Assessment of Outcome j) - Contemporary Issues

Assessment Method	Performance Criteria	Source	Acceptance Criteria
Direct Assessments	Energy Issue Questionnaire	EE 330	80% avg per question
Course based assessments	Climate Change Essay	CENG 447	rubric score >=3
Indirect Assessments	Question 25	Senior Exit Survey	rubric score>=2.5
Constituent Surveys			

Table 4-18 - EE330 (Energy Systems) Rubric to Assess Outcome j)

Energy Issues - Assessment Rubric

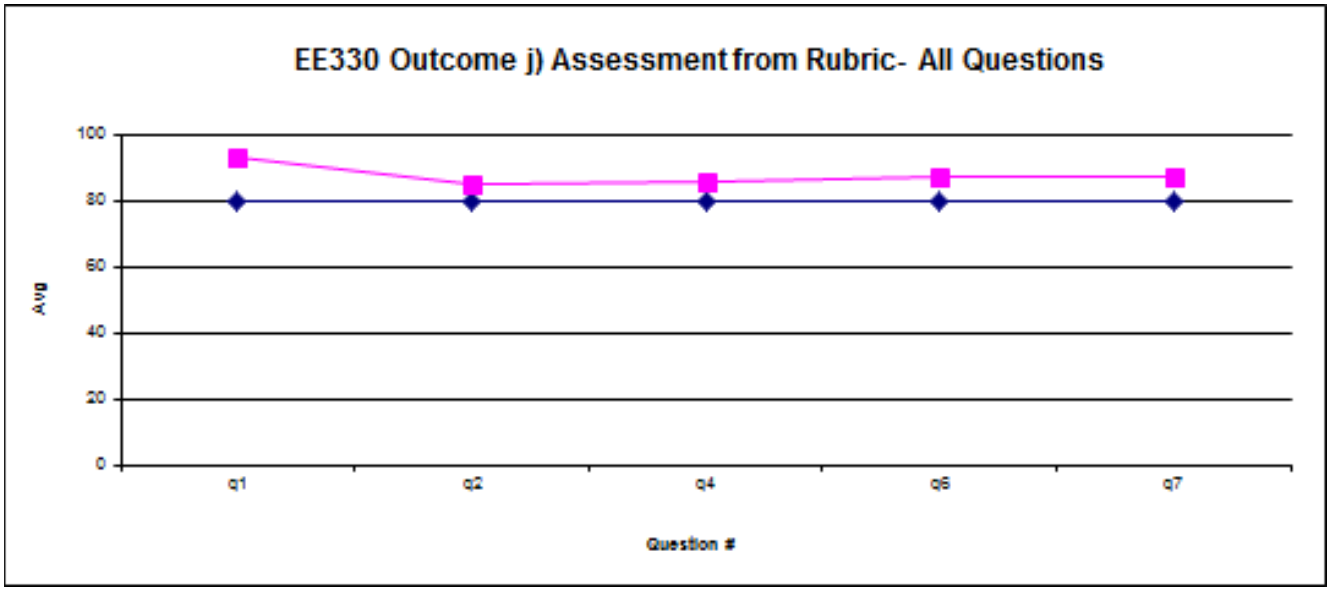
Notes: a) Contemporary Issues lecture
b) Energy usage, standard of living, coal as fuel source
c) A >= 90%, 80% ,<= B < 90%, 70% <= C < 80%, 60% <= D < 70%, F < 60%

Content	Unfamiliar	Apprentice	Acceptable	Qualified	Professional
Energy Usage & Standard of Living 20	No awareness of relationship 10				Relationship throughout history 19
Scope of Energy Usage 20	None listed 10	One identified 13	Two identified 15	Three identified 17	Four identified 19
Trends of Nuclear, Coal, Renewables, Petroleum as Power Plant Fuel 20	No trend correctly identified 10	One trend correctly identified 13	Two trends correctly identified 15	Three trends correctly identified 17	Four trends correctly identified 19
Coal Reserves 20	No response 10		Reasonable, qualitative answer 15	Correct, qualitative answer 17	Correct, quantitative answer 19
Issues Facing Coal 20	No response 10	Answer reflecting mass news media perspective 13	Answer including energy production perspective 15	Answer including energy production & political perspective 17	Answer including energy production & political factors, and economic factors 19
traditional grade --> Total points = 100	F	D	C	B	A

energy rubric rev -.ppt

Rubric results are shown below:

Figure 4-40 - EE330 (Energy Systems) Results of Outcome j) Assessment



The students seemed to be interested in the subject matter, since a big part of our local economy is dependent on coal mining. Of course, there is much in the news regarding coal mining, global warming, regulation and the political aspects of this issue. The average of responses to all questions exceeded the 80% threshold.

The rubric and assessment using CENG447 data is shown below:

Table 4-19 - CENG447 (Embedded Systems) Results of Outcome j) Assessment

A knowledge of contemporary issues.

Performance Indicator	1: Unacceptable	2: Marginal	3: Acceptable	4: Exceptional	Points*	Score
Climate Change Report	Report consists only of a summary of one or two required scientific references. Report is missing one or more of the key requirements: introduction, conclusion, personal stance, reference documentation or an engineering design. 0	Report is a cursory statement of the writer's personal stance with limited support from reference material. Report covers one or more of the key elements in a rudimentary fashion. The engineering design is marginally presented or discussed. 0	Report is a composite of the writer's personal stance with some support from reference articles. Report contains all key requirements of the assignment: introduction, conclusion, personal stance, or an engineering design. 2	Report is well thought out and contains a composite of the writer's personal stance as well as multiple references to support that stance. The engineering design is thoroughly presented and relevant schematics and drawings are included. The report is presented in a logical manner which leads to the writer's concluding remarks. 17	74	3.9

Results from this assignment were gratifying, since there were many ideas for embedded systems containing various kinds of sensors to measure and analyze the CO_2 content of the atmosphere. Scores are included in the rubric above, showing thoughtful responses were received from the students.

The rubric and assessment data using senior exit survey is shown below:

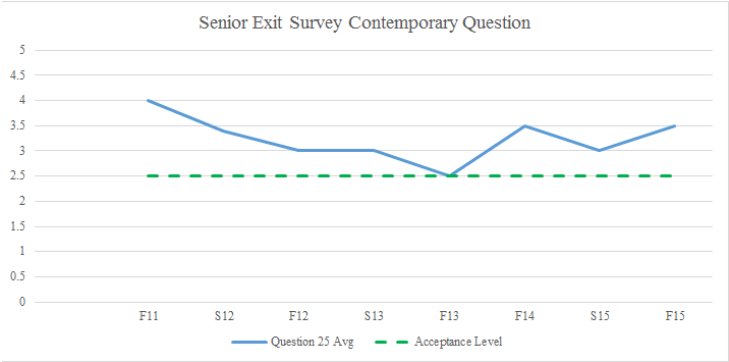
Table 4-20 - Senior Exit Survey Results of Outcome j) Assessment

Rubric for Performance Indicators Of Abet Outcome (J)

A knowledge of contemporary issues.

Performance Indicator	1: Unacceptable	2: Proficient	3: Excellent	4: Exceptional	Points*	Average
Qu. 25 Please write down three contemporary issues that you feel will be very relevant to future world events and discuss how your major (EE or CENG) impacts these issues.	No answer given or the answer was not actually relevant to the question. 0	The answer is a basic response relevant to the question with three responses relating to only one contemporary issue. 0	The answer is both relevant to the question and includes three responses relating to two contemporary issues. 0	The answer is relevant and expands to give three or more separate contemporary isses. 0		

Figure 4-41 - Senior Exit Survey Results - Outcome j)



On occasion, it appears that some of the seniors did not answer this questions (the last question on the senior exit survey) which results in some low scores.

Based on the results of our assessments of outcome j), we conclude that we meet the requirements of this student outcome, and that students will be prepared to enter the workforce with an awareness of the many non-technical issues that they will face.

11. Outcome k) - Tools

All courses in any engineering curriculum exist to give student those techniques and skills needed for engineering practice. The practical part of most engineering courses includes laboratories which teach the student how to use modern engineering tools necessary to accomplish the technical task. Samples from student assignments using the tools specified in every required course are included in the outcome k) binder.

The actual assessment of this outcome is accomplished through questions 12 and 13 on the senior exit surveys. Each question has 11 "tools" used throughout the students' academic experience. Question 12 asks the student to rate what their ability to utilize these tools are on a 1 to 5 scale—5 being the highest. Question 13 asks the student to rate which tools they felt they needed more education or experience using. This scale is also a 1 to 5 scale with 1 meaning it needed the most additional education. The 11 tools are aggregated into 3 categories: technical tools (programmable calculator, personal computer, internet, library), test equipment (oscilloscope, multi-meter, signal generator), and software / simulation tools (C, Java, PSPICE, MATLAB, etc.)

Figure 4-42 - Senior Exit Survey Results -Tool Usage Competency

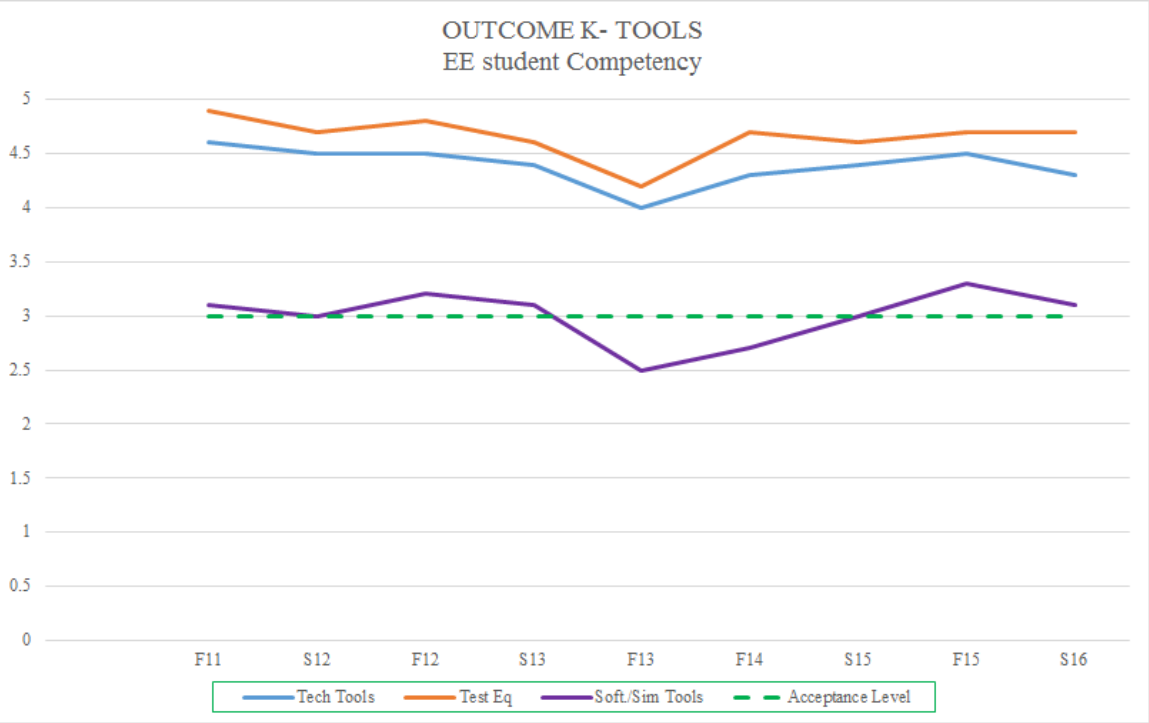
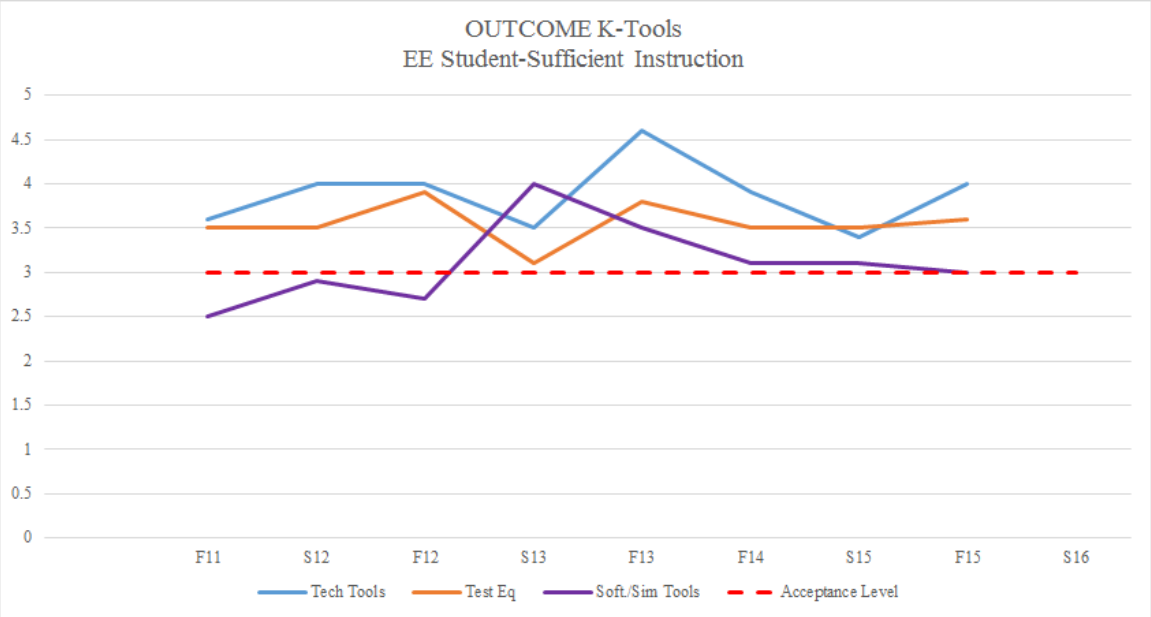


Figure 4-43 - Senior Exit Survey Results - Sufficient Instruction



The spring '16 data is removed because some of the surveys completed by students did not have this question included. The survey will be repaired prior to administration in the fall of '16.

Over the 6-year assessment period, students feel that they meet the assessment criteria for confidence in their ability to utilize these tools. However, it has been a continuing problem, and is reflected in the assessment of question 13 that students want more education and experience with many of the tools- in particular the software and simulation tools. Starting in the fall of 2016, the department will be working with the student IEEE branch to provide evening help sessions on the various tools, especially MATLAB. We are planning to standardize on a version of PSpice that is part of our circuit board CAD software which will reduce the number of different versions of PSpice used in our courses. The issue with PSpice has been one of faculty familiarity with a particular PSpice vendor and reluctance to learn another vendor's version. We will be making a staffing change in the next budget cycle and will have a resource person trained in the Altium PSpice tool, and that person will be able to support students giving the instructors more time to learn the Altium version of the program.

C. Additional Information

For the site visit, we will have a conference room reserved for our evaluator(s) in which the following resources will be available:

a) - a copy of the Self Study including appendices & attachments
b) - Student Outcome Assessments (one binder for each of the a - k outcomes)
c) - Course binders (to include student work samples & course outcome assessments)
d) - Industrial Advisory Board meeting minutes
e) - ECE department meeting minutes
f) - Student survey results binder
g) - Course textbooks
h) - Degree audits

We will also host:

a) - lab and facility tours
b) - faculty interviews
c) - student interviews