

CRITERION 4. CONTINUOUS IMPROVEMENT

A. Program Educational Objectives

The Program Educational Objectives for the Mechanical Engineering program are as follows:

Within a few years of graduation, our graduates are expected to:

1. Apply engineering knowledge and skills to make positive impact on society through employment in industry, advanced study, and/or public service;
2. Communicate effectively and perform professionally in both individual and multi-disciplinary team-based project environments;
3. Be engaged in and continue to engage in lifelong self-directed learning to maintain and enhance their professional skills;
4. Determine and respond to ethical implications on issues such as public safety and intellectual property protection, and also reflect on global and societal impacts of engineering solutions to contemporary problems;

These PEO's were chosen by the ME faculty after a significant amount of discussion during faculty meetings, a faculty retreat, and via email. They were developed based on faculty experience, evaluation of other ME programs throughout the country, and ABET guidelines. The Industrial Advisory Board met in March 2011 to evaluate whether they believe that these are the proper PEO's for our department.

Alumni surveys were sent out in Summer 2010 and received back in Fall 2010. Of 469 BSME alumni graduated within the last 5 years, 42 alumni responded to the survey. A summary of responses related to the PEOs from both alumni and the industrial advisory board are shown below. Each advisory board member rated the importance of each PEO on a scale of 1-5 with 5=very important, 4=important, 3=lesser importance, 2=not important, 1=not relevant.

PEO #1 – Ninety percent of respondents are working in industry in areas related to mechanical engineering, attending graduate school, and/or providing public service. With the difficult economic times, 10% are unemployed. The advisory board members all rated this PEO with a score of 4 or 5 with an average of 4.6.

PEO #2 – Eighty-three percent of respondents have made presentations at work or in conferences since graduation. About 36% of the responses have provided training/workshops either at work or outside organization, and the same percentage have prepared/produced publications and reports since graduation. Furthermore, 90% claimed that they have demonstrated teamwork skills at work, 86% have demonstrated it by applying effective listening skills in team interactions, 76% have presented alternative strategies to problem solving in a professional way; 66% have contributed to company strategic decisions through work or participation in team planning and execution; 57% have motivated others toward a common goal in a team, and 57% have contributed to the professional development of co-workers through mentorship or peer guidance. The advisory board members all rated this PEO with a score of 4 or 5 with an average of 4.5.

PEO #3 – Thirty-five percent of respondents have attended an MS or MBA program full- or part-time, and the same percentage had been enrolled in certificate programs or other part-time training. Forty-five percent were current members of professional societies, and the same percentage have passed the Fundamentals of Engineering Exam (typically taken their senior year). The advisory board members rated this PEO from a score of three to five with an average of 4.3.

PEO #4 – Fifty-seven percent of respondents reported that they have had the opportunity to apply the skills learned at SJSU regarding societal, environmental impacts and safety. They have done so by developing or modifying a product or manufacturing processes with regards to product safety, implementing existing corporate practices or developing improved practices for societal impacts and safety concerns and elucidating and documenting the environmental impacts of product or manufacturing process or some aspect of the design process. Furthermore, 90% of the respondents have either determined or responded to ethical implications/choices for projects at work. Of those 38 alumni, 32 of them (84%) indicated that they have respected individual and/or company's intellectual property; also 32 (94%) have used legitimate licensed software in project work; 28 (87.5%) have followed Engineering Standard guidelines/practices in product design and development; 22 (58%) have contributed to material selection in projects that minimize potential health hazard for users; and 13 (34%) have contributed to company decisions on areas of product marketing, liability, and safety.

The advisory board members rated this PEO from a score of three to five with an average of 4.0.

The alumni surveys indicate that the PEO's are being achieved by our graduates, with a strong majority in particular achieving PEO's 1 and 2. This conclusion would be stronger if a greater number of alumni surveys were returned. In future years, alumni surveys will be sent out and assessed a minimum of every three years, two if the response rate is low. The industrial advisory board members all thought that the PEO's chosen were appropriate and important measures of achievement of graduates. Additionally, the board members' ranking of importance of the PEO's matches with the faculty's, with PEO #1 rated most important, #2 rated slightly less, and so on.

The Industrial Advisory Board also brainstormed about what the ideal engineer should look like three to five years after graduation. This was done before we showed them our PEO's. A summary of what the board discussed is shown below.

The ideal engineer three to five years after graduation:

- Has the technical skills to solve multi-disciplinary problems.
 - Knows the fundamentals to tackle tough problems.
 - Has hands-on skills to trouble-shoot and solve problems.
 - Is able to set up an accurate computer models and perform a sanity check on results.
 - Is able to identify choke points/bottlenecks of a project.
 - Is able to provide 1st order results quickly.
- Has a demonstrated ability to work on a team as well as take leadership for a project.

- Is able to work on and form teams with engineers with different areas of expertise.
 - Is able to work and communicate with constituents in other counties.
 - Is able to effectively manage a project.
 - Knows when to ask and where to go for assistance.
 - Does not hinder progress on projects by a fear of failure.
 - Has strong oral and written communication skills.
- Has an understanding of the company business.
 - Knows how their projects fit in with the company's goals.
 - Understands the economics of the project through the entire lifecycle and how they fit in with the company's "big picture".

The results of this open-ended discussion mesh well with our PEO's. The members, being focused on their own company performance, did not bring up larger issues such as societal and ethical implications that our PEO's, which look more globally, address, but this is to be expected. Despite this omission during the open-ended discussion, the board members agreed that the PEO's that address these issues are important. Perhaps the only area that the board members brought up that is not addressed by our PEO's is in the area of project planning, including economics. Some of these skills will be learned on-the-job and may be particular to the company. However, during the next cycle of assessment, the faculty will consider whether revision of the PEO's (and hence, curriculum) is needed to incorporate these issues. Further assessment will be done when the full Industrial Advisory Board meets during the 2011-2012 academic year.

Student Outcomes

Program improvements are made based on feedback from the Industrial Advisory Board (IAB), alumni surveys, and course and program assessment. In the future, the IAB will meet yearly to address needed changes in PEO's and curriculum as well as how to improve the university's interaction with industry. Alumni surveys will be collected every three years at a minimum and will be used to address program strengths and areas in need of improvement or change. Course assessment will be continuous, with several outcomes addressed every year as discussed later in this section.

For the current cycle, more limited information is available. The sole set of alumni surveys was collected in Fall 2010. Many faculty members have had interaction with individual industry members throughout the six-year cycle. For example, industry members sit on senior design and master's student review committees. However, a full IAB was not convened until Spring 2011. Thus, it was too late to implement changes based on feedback from these constituents.

Outcome assessment based on coursework has been carried out on a more continuous basis. Students have multiple opportunities to achieve each outcome, as shown in Table 4-1 below. Checked boxes indicate courses that contribute towards an outcome but are not currently assessed. An "M" indicates a medium contribution to outcome achievement, "H" a high contribution. This table only includes a subset of courses required for graduation; all assessment is performed using only these classes.

Table 4-1 ME Program – Outcome Matrix

Student Outcomes											
	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	3k
E10	✓	✓	✓	✓	✓	M	✓	✓	✓	✓	✓
E100W						✓	H	✓	M	M	
ME101	M				✓						
ME106	✓	✓	M	M	H		✓		✓		H
ME111	M			✓	M		✓	✓	M	H	
ME113	M				✓		✓	H	✓	H	M
ME114	H				✓					✓	
ME115	✓	✓		✓			M				M
ME120	M	H		✓	✓		H		✓		✓
ME 130	M										
ME154	✓		M	✓	H		✓		✓		H
ME 195 A, B	✓		H	H	✓	M	✓	H	✓		✓

M: Medium contribution

H: High contribution

✓ Skills relevant but not presently assessed

The plan after the last ABET visit was to assess three to four outcomes every year, resulting in assessment of each outcome at the minimum every three years. Results were to be discussed in full faculty meetings. Changes would be implemented to improve performance of outcomes not achieved and reassessed during the next course offering until target goals are met, with results reported in faculty meetings. This is the plan for the assessment process in the future. Figures 4-1 and 4-2 show the program improvement process based on coursework assessment.

Course Assessment Flow Diagram

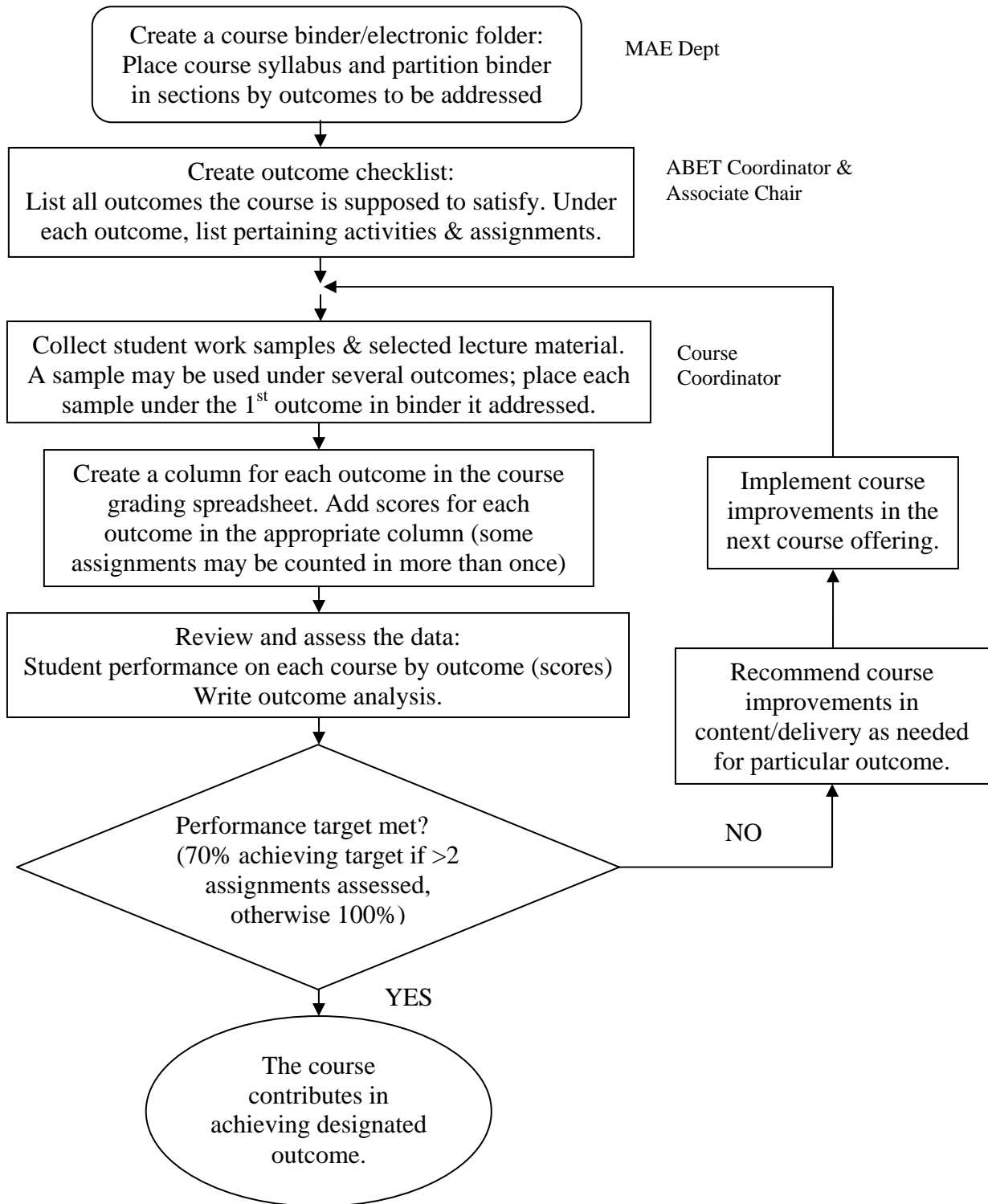


Figure 4-1 Course assessment flow diagram

Outcome Assessment Flow Diagram

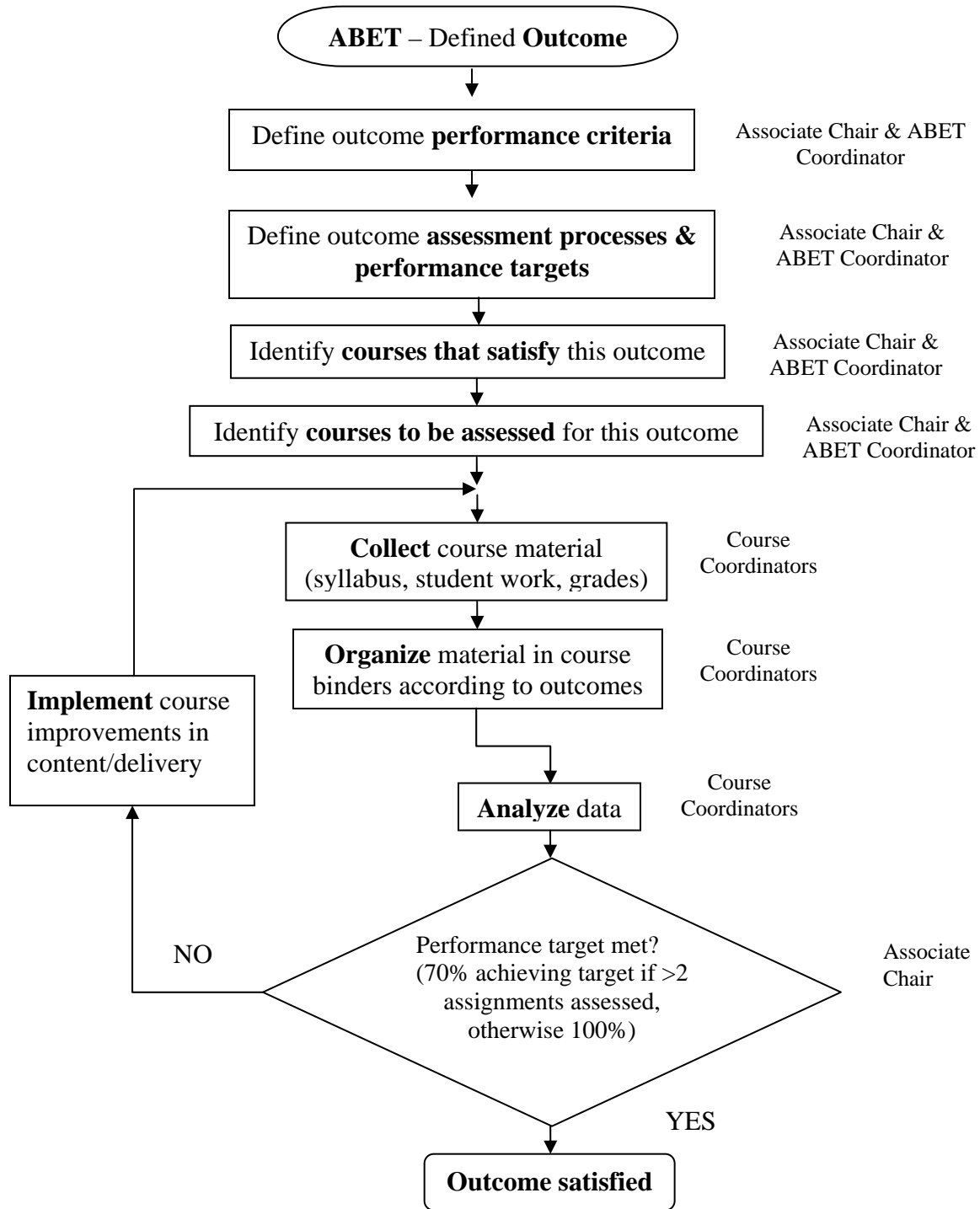


Figure 4-2 Outcome assessment flow diagram

While the assessment process in the flow diagrams has been followed, the schedule of assessment deviated from the original plan. Improvements were implemented in 2006 after the last ABET review and assessed during 2007. These include both course improvements and an overall program improvement, and results were presented in faculty meetings as planned. However, following 2007 disruption in department administration resulted in cessation of the regular assessment cycle with the exception of limited assessment performed in 2009. This is also the reason why the IAB did not meet as planned. In 2010 the regular department administrative process was re-established, and at that time the assessment process was restarted. Since several years of the cycle were missed during this time, all outcomes were assessed from Spring 2010-Spring 2011. Improvements have been identified, implemented, and assessed. If the target was met in the courses chosen for assessment of an outcome in Spring or Fall 2010, the outcome was achieved and no further action was needed in Spring 2011. Results of course assessment have been discussed in detail in multiple faculty meetings.

A listing of assessment processes from coursework is given in Table 4-2.

Expected levels of Outcome attainment

All students in the Mechanical Engineering program must achieve a C- or better in each class in their major (all classes excluding general education courses). Thus, this is considered the minimum acceptable achievement for a student. Realistically, all students will not achieve a C- or better for all assignments. Thus, with the exclusion of Outcome i, all outcomes are assessed using assignments from multiple classes. When one or two assignments are assessed, the goal is to have 100% of students achieve the target level on at least one. If more assignments are assessed, the goal is 70% achievement. Over time as the program improves, this goal of 70% achievement can be increased since truly the ideal is 100% achievement of each assignment and outcome.

Summaries of assessment results

After each outcome, the performance evaluation criteria used to evaluate the outcome are listed, followed by a summary of analyzed data and conclusions relating to level of achievement of the outcome.

Table 4-2 Assessment Processes and Semesters of Data Collection for Each Outcome UPDATE AFTER S11

Outcome 3a	Outcome 3b	Outcome 3c	Outcome 3d
ME 101 course grade F10 ME 111 homework assignment F10 ME 113 gateway quizzes F07, S10, F10 ME 113 homework assignment F10 ME 113 course grade F10 ME 114 quiz F10 ME 120 homework assignments ME 130 final exam question F10	ME 120 individual. lab reports S10, F10 ME 120 individual oral pres. S10, F10 ME 120 group project report S10, F10	ME 154 group design report S10, F10 ME 154 homework assignment S10 ME 154 quizzes S10 ME 106 individual lab reports S10, F10 ME 106 group project report S10, F10 ME 195 group project reports F10	ME 106 term project reports S10, F10 ME 106 performance eval. forms S10, F10 ME 195 project topics F10 ME 195 performance evaluation forms F10
Outcome 3e	Outcome 3f	Outcome 3g	Outcome 3h
ME 111 homework assignment F10 ME 106 term project, mini-project, and lab exercises S10, F10 ME 154 project S10, F10	Engr 10 homework assignments F10 Engr 10 final exam questions F10 ME 195 quiz F10 ME 195 group project reports F10	ME 115 lab report F10 ME 120 individual oral pres. S10, F10 ME 120 lab reports S10, F10 Engr 100W exit exam 07-09 8 Engr 100W written assignments F09	ME 113 papers S07, 09, 10, F10 ME 195 group project reports S09, F10
Outcome 3i	Outcome 3j	Outcome 3k	
# of students involved with clubs F10 # of student competition awards F10 ME 111 group project reports F07, F10 Engr 100W assignment F09 student survey S11	ME 111 group project reports F07, F10 ME 113 exam questions F10 ME 113 papers S07, 09, 10, F10 Engr 100W assignment S10	ME 106 individual lab reports S10 ME 113 assignment S10 ME 115 computer assignment F10 ME 154 assembly drawings S10, F10 ME 154 assignment S10 ME 154 group design report S10, F10 ME 154 presentation or DVD S10, F10	

Outcome 3a -- an ability to apply knowledge of mathematics, science and engineering
ME graduates can:

1. Use math (calculus, differential equations, linear algebra) to solve ME problems.
2. Use science (chemistry, physics concepts) to solve ME problems
3. Use engineering principles (Newton's laws, fluid mechanics, thermodynamics, heat transfer etc) to solve ME problems

Math, science, and engineering principles are used in every class in the major. For example, calculus is used integrate forces on a surface in Fluid Dynamics. Differential equations are used to analyze heat conduction in Heat Transfer. Chemistry is used in many places in Introduction to Materials, and much of Statics and Dynamics rest on the laws of physics. While each course in the major contains major elements towards this outcome, to show that our students are achieving it we are showing analysis of data from five courses – ME 101 Dynamics, ME 111 Fluid Dynamics, ME 113 Thermodynamics, ME 114 Heat Transfer, and ME 130 Engineering Analysis. Assessment results for an assignment for each of these courses are presented below.

ME 101 Dynamics

There were 67 students enrolled in one section of ME 101 and 68 in a second section in Fall 2010. This evaluation is based on the performance of all students who completed the class. This particular class requires a combination of skills including calculus, differential equations, physics concepts, and engineering principles simultaneously to solve mechanical engineering problems. The main engineering principles for this course are Newton's laws, work and energy, and impulse and momentum. All three of the identified performance criteria are evaluated collectively based on final exam performance. Some students did use linear algebra to solve systems of linear equations with unknown variables and independent equations, but linear algebra methods are not specifically mandated.

Using a minimum passing grade criterion of "C-" or higher 83% students in Section 1 and 91% in Section 2 met the proficiency criterion. Any students receiving a final course grade of less than a C- are required to repeat the class to achieve minimum proficiency.

Implemented Improvement: In the professional opinion of the course instructor, the students who performed poorly generally had gross shortcoming in basic proficiency with vector algebra, calculus, and free-body diagrams. These skills are fundamental to pre-requisite courses Math 32 (Calculus III) and CE 99 (statics). In this semester, there was no formal way of enforcing that students meet a minimum grade (other than "D-") in these pre-requisites. The department has initiated changes to specific wording in the University Catalog to enforce minimum grade requirements for these pre-requisites (C-), effective 2011. This change is discussed in more detail, including supportive data, in section 4-C.

ME 111 Fluid Dynamics

Two sections of this course were offered in Fall 2010, and one assignment was used to assess this outcome. This homework assignment contains six problems on the topic of fluid forces on or by jets, vanes, nozzles, pipe bends, propellers, and valves. The scores are summarized below:

Section 1	Section 2
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Mean: 69%	Mean: 96%
StDev: 18%	StDev: 8%
%Students > 70%: 68%	%Students > 70%: 98%

These homework assignments provide evidence that students can apply the principles of momentum, energy, and control volumes to solve fluid mechanics problems although 32% of students did not achieve minimum acceptable performance in one section.

ME 113 Thermodynamics

ME 113 was used to show that students can

1. Use science to solve ME problems
2. Use engineering principles (in this case laws of thermodynamics) to solve ME problems.

Implemented Improvement: In previous semesters, some students struggled with basic thermodynamics concepts until the very end of the semester. As a result, two “gateway” quizzes have been installed in the first third of the semester. Students must pass these quizzes to pass the class. Their score the first time they take the quiz is the score that factors into their final grade. These quizzes are given in class. However, if students score below a 70%, they are required to take a new quiz on the same topic online. This quiz can be retaken up to three times. The second quiz focuses on applying the first law of thermodynamics. Of the 113 students in class in Fall 2010, only one student out of 113 failed to pass this quiz after retaking it online. He will have to retake the course. After implementing this change, Exam 1 scores (which is the exam covered by this topic) rose from an average of 65% in Fall 2007 to 70% in Spring 2010 when the first gateway quiz was implemented and 74.5% in Fall 2010 when the second gateway quiz was implemented.

In ME 113 students must use chemistry and physics topics. For chemistry, students must use laws of thermodynamics, the ideal gas law, and Kay’s rule, all for non-reacting gas mixtures. This requires them to calculate quantities such as mole fraction, molar mass for mixtures, and the gas constant for mixtures. This topic was covered on the final exam as well as on the last homework assignment for the semester. Students are allowed to drop 2/11 homework assignment scores for the semester, so on each assignment approximately 80% of students are expected to turn it in. The topics that they miss are covered on quizzes and exams, so they still must learn the material. On this homework assignment, 74% of students had acceptable scores (C- or above).

Most of the topics in ME 113 can also be considered physics topics. Thus, the final scores for the class are an indicator of the students’ abilities in these areas. In Fall 2010, 25/113 received scores below a C-, which is considered the minimum acceptable level. However, students must achieve a C- or better in all technical classes to graduate, so those students not succeeding the first time must retake the class until they do. Thus, eventually 100% of students reach acceptable levels of applying both physics and engineering principles in this course, and the outcome is achieved.

ME 114 Heat Transfer

This course has been used to show that students can use differential equations to solve ME problems. While differential equations are used in several locations in this class, for assessment purposes the results of one quiz in Fall 2010 are shown here. In this quiz, students must choose the correct form of the heat conduction equation needed to analyze a cylindrical heat conduction problem, simplify it, integrate, apply boundary conditions, and solve the equation. On this quiz, the average score was an 89% with a standard deviation of 23%, and 81% received a C or better.

ME 130 Engineering Analysis

ME 130 covers linear algebra (along with many other topics). Students learn where linear algebra is used in engineering applications. They learn to perform matrix algebra and use matrix inversion and Gaussian elimination to solve sets of simultaneous equations. Types of matrices include rectangular, square, row and column, upper and lower triangular, diagonal, and unity matrices. The average score on one homework assignment covering these topics was a 68%. A final exam question where students used Gaussian elimination to solve a set of simultaneous equations was also assigned. The scores the 44 students in Fall 2010 in the final examination received in the problem of linear algebra appeared polarized with 16 students scoring below C-grades, but 12 students scoring with a top grade of A+. The average grade was B-.

Add statistics data from Spring 2011.

Outcome 3a Conclusions

Every course in the program has a significant number of assignments relating to this outcome. With the minimum course grade for graduation of C-, no student can fail to achieve this outcome in any course. Calculus, differential equations, linear algebra, science, and engineering principles are all applied in many courses. While some individual students have had problems with linear algebra, this topic is not critical enough in the program to keep students from achieving the outcome based on their application of the remaining areas of math, science, and engineering principles. In addition, a survey of graduates 1-5 years out showed that they thought SJSU provided a strong foundation in math (82.7%), science (93.1%), and engineering principles (100%).

Outcome 3b -- ability to design and conduct experiments, as well as to analyze and interpret data

ME graduates can:

1. Based on an identified problem, design an experiment to acquire data to solve a problem
2. Select appropriate equipment/instrumentation for an experiment to determine/measure the value of dependent variables from the given values of independent variables.
3. Calibrate the instruments from an experimental setup and follow procedures to collect data
4. Perform necessary calculations, error analysis, interpret data, and draw conclusions from a given set of data

Students gain experience in this area in many classes that include labs– all physics courses, chemistry, MatE 25 Introduction to Materials, ME 106 Fundamentals of Mechatronics, ME 115 Thermal Engineering Laboratory, CE 113 Mechanics of Materials Lab. The students perform at the highest level on Bloom’s Taxonomy in ME 120 Experimental Methods, so that is the course that is assessed for this outcome.

ME 120 has one 50 minute lecture and one three-hour laboratory session per week. There are six directed experiments that give students hands-on experience with various sensors, test and measurement instruments, and data acquisition hardware and software. Each directed experiment has a set of instructions that introduces the background of the experiment, the instruments, and the experimental procedure. The students work mostly in pairs to perform the experiments. Each student must *individually* write a report that describes what was done and what was found.

In addition to the directed experiments, students work in teams to devise and carry out an open ended experiment of their own choice as a term project. The team documents the experiment and their findings in a written report and presents it to their classmates in oral format using presentation software. The lecture portion of the class teaches the students how to properly design this experiment. Some of the lecture topics in class used to prepare students for this task are as follows:

- Probability distributions (1 lecture class): This lecture teaches the student basics of statistics including parameters of central tendency (mean, mode etc.) and dispersion (variance, standard deviation etc.). Also students learn how to compute the probability of a measurement falling within in certain range of values using standard normal distribution tables.
- Parameter Estimation (1 lecture class): The lecture teaches the student to evaluate the estimates of the parameters (mean and standard deviation) by applying confidence intervals. Here we talk about z-statistic, t-statistic and chi-squared statistics.
- Regression and Correlation (1 lecture class): This lecture teaches the student the treatment of random data using correlation and regression. Here they talk about least squares fit, different regression models (linear, non-linear etc.), goodness of fit and outlier removal.
- Uncertainty analysis (1 lecture class): This lecture teaches the student to conduct the uncertainty analysis on the experimental data by classifying the measurement error into systematic and random components and then compute the combined uncertainty. This includes worst case scenario and the RSS method.

Data from the grade record of ME 120 in Spring 2010 show that no students scored less than 73 out of 100 on their written reports for the six directed experiments. Also, no team scored less than 8.9 out of 10 for their oral presentation or term project report. These results are very positive; however, it was recommended that the current scoring rubric could be improved by including more specific criteria to assess the students’ ability to design and conduct experiments, and analyze and interpret data. For example, it would be helpful to include categories that specifically address:

- Selection of appropriate equipment and instrumentation

- Calibration of instruments
- Comparison of theoretical predictions to empirical results
- Discussion of error sources and error analysis

The grade record of ME 120 in Fall 2010 shows that, aside from those who received zero for either failing to turn in a report or plagiarizing a report, no student scored less than 80/100 for written lab reports on experiments 1 – 5 (average = 90.6). For experiment 6, of the 88 non-zero scores, 87 scored at least 80/100 (average = 87.4), while one student received 10/100. For the term project, no team scored less than 88/100 for the written project report, and no student scored less than 84/100 for the corresponding oral presentation.

Implemented Improvement: As a result of feedback from the Spring 2010 assessment, changes were implemented to the scoring rubric this semester for both the written report and oral presentation for the term project to include each of the bulleted items listed above.

The average scores for lab reports 1 through 3 and the term project were statistically similar compared to those in spring 2010 (approximately 92 to 93/100). The average scores for lab reports 4 through 6 (approximately 87 to 90/100), and the oral presentation (93/100) were three to five points lower than their spring 2010 counterparts.

Outcome 3b Conclusions

The results from ME 120 are very strong and support the conclusion that this outcome is being met. This conclusion could be bolstered if subscores for the bulleted items were to be reported.

Add fall 2010 subscore assessment when available

Outcome 3c -- 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

ME graduates can:

1. Based on an identified need, define a problem statement in engineering terms
2. Generate design concepts for a system, component or process and select the most suitable one based on the constraints in economics, environmental, ethical, health and safety, manufacturability etc.
3. Develop design specifications (materials, geometry, operating parameters etc), perform analysis and design verification

Students are taught the design process in several classes, including Engr 10 Introduction to Engineering, ME 154 Mechanical Engineering Design and the three capstone courses (ME 157, 182, 190 – students choose one based on their focus area). For assessment purposes, we are presenting data from ME 154 Mechanical Engineering Design, ME 106 Fundamentals of Mechatronics Engineering and ME 195a and b Senior Design Project.

ME 154 Mechanical Engineering Design

In the ME154 class, students are taught the design process using a flow chart showing several key steps, and it is presented in the early part of the course. Students work on team group design projects of their choice. Typically, two design review sessions (held in late Sept and late Oct) are conducted in class with each individual project group to review project team design concepts in

the first meeting and engineering synthesis/analysis work in the second meeting. Verbal feedback from the instructor is given to each design team at those meetings. The design process in this course consists of:

1. Identification of a need
2. Background research on the topic
3. Design goal statement and project objective(s)
4. Design concepts generation and selection
5. Engineering synthesis and analysis
6. Detailed design
7. Prototyping and testing

The analysis presented below is based on Spring and Fall 2010 assessment data.

PEC 1: Based on an identified need, define a problem statement in engineering terms

ME154 requires students to perform a group design project applying kinematic mechanism(s) learned from the course. A group of three to four students work together throughout the whole semester to design a mechanism or device to perform a meaningful task. Each group submits a project report at the end of the semester. There were nine groups in this Fall 2010. Based on the project reports, seven out of nine projects (approx. 78%) had identified the need to be addressed and provided a clear problem statement in their reports. In Spring 2010 in a slight variation, students were required to complete a written Project Proposal, which required identifying an engineering need and articulating functional purpose of a designed mechanism. The assignment was graded by A-F letter grade. A total of 49 of the 57 (86%) students passed with grade of C or higher, and all students passed with C- or higher.

PEC 2: Generate design concepts for a system, component or process and select the most suitable one based on the constraints such as those in economics, environmental, ethical, health and safety, manufacturability etc.

In Fall 2010, all project reports presented various design concepts and the best concept was chosen for the final design based on design constraints such as cost effectiveness, safety issues, and manufacturability. Therefore, 100% of the design project reports from students satisfied this criterion. In addition, in Spring 2010 students were required to complete an assignment on Graphical Linkage Synthesis. The assignment required students to generate multiple design concepts and to determine the associated mechanism geometry while exercise this particular skill set. The assignment was graded by A-F letter grade. Fifty-three of the 57 students (93%) passed with grade of C or higher, one student received a marginal grade of C-, and three students failed to submit the required assignment. This assignment was not specifically based on the constraints in economics, environmental, ethical, health and safety, or manufacturability. Although this particular assignment is not perfectly aligned with this performance criterion, it did focus on generating design concepts that would subsequently be justified for merit based on such broader considerations.

PEC 3: Develop design specifications (materials, geometry, operating parameters etc), perform analysis and design verification

In Fall 2010, out of nine groups, seven of them have explicitly stated design specifications for the project in their report. Design analyses were also performed at acceptable level in those projects. All groups were required to build a scaled prototype to demonstrate the functionality

and performance of their design, though only seven out of nine projects had successfully verified their designs using the prototype. Therefore, only 78% of the class met this performance criterion.

In Spring 2010, “spot quizzes” were also used to show individual achievement of this outcome. There were eight short (15-20 minutes) in-class quizzes distributed throughout the semester, primarily focusing on the “perform analysis” aspect of this performance criterion. There were 57 students and each spot quiz was graded by A-F letter grade. Fifty-three of 57 of students (93%) passed with average spot quiz grade of C or higher, three students earned a marginal average grade of C-, and one student earned an average grade of D.

ME 106 Mechatronics

ME 106 consists of two 50 minute lecture and one three-hour laboratory session per week. There are nine directed laboratory exercises that give students hands-on experience with electronic test and measurement instruments, electronic circuits and devices, sensors, actuators, microcontrollers, and embedded software. Lab exercises lead the students through discovery and application of fundamental concepts in mechatronics. The students work in pairs to perform the exercises. Each student must *individually* write a report that describes what was done and what was found.

In addition to the directed laboratory exercises, students work in teams of two to five to design a mechatronic system as a term project. The team documents their design and design process in a written report and presents it in a project exhibition at the end of the semester.

The term project is the primary instrument that is used to assess Outcome 3c. The students are given a very detailed guideline which explains the rationale for the assignment, lists the deliverables, and suggests a process for completing the assignment. The basic idea is that students in teams of approximately two to five must design a mechatronic device which is comprised of at least one sensor, at least one actuator, mechanical components, and must be controlled by a microcontroller. Some students also take ME 154 Mechanical Engineering Design in the same semester. ME 154 also requires an open-ended design project that primarily emphasizes mechanism design, and students taking both classes are encouraged to devise a project that satisfies requirements of both classes. The open-ended nature of the term project in ME 106 unleashes significant and wide ranging creativity in what the students design.

Spring 2010 Results:

The samples of the term project report suggest that students in ME 106 are able to design components and a system to meet a desired need. Several of the reports in the sample showed a relatively high level of competence in design and skill in fabrication. All the samples showed an ability to define a problem statement in engineering terms and generate at least one design concept that met the basic design requirements set out by the instructor. The average score on the project was about 21/30 with a standard deviation of 4.4 (N=73).

Two of the six reports had modeling and analysis to provide analytical support for the design. The two were joint ME 154/ME 106 projects, where a specific requirement for the ME 154 project report is analysis of the mechanism used in the design. All of the samples reported success in meeting their objectives, but few included specifics about testing that was done

Implemented Improvement in Fall 2010:

One noted area for improvement in addressing this outcome was to require that the project report clearly articulate the design requirements, especially those that go beyond the basic ones set out by the project guidelines. Other noted improvements included required documentation of:

- Multiple design concepts
- Description of the method used to arrive at the chosen concept
- Design verification by analysis and testing

As a result of these recommendation, the grade for the project in Fall 2010 was changed to evaluate each element of the design process separately. More explicit instructions were given in the Term Project guidelines for Fall 2010 regarding design specifications and their inclusion as a separate section in the Project Report. The grade for the project is determined as a weighted sum of scores for the following sub-elements:

- **Concept (25%)** The technical merits of the design, including, innovation, appropriate use of hardware and software, and application of physical and engineering principles.
- **Implementation (25%)** How well the concept was implemented in hardware, where the focus is on the quality of workmanship and finished appearance.
- **Performance (25%)** How well the project performed during the project exhibition.
- **Report and Poster (25%)** How complete and well-written the documentation of the design is. The key criteria is, “How easy would it be for someone acquainted with Mechatronics to understand, reproduce, and/or modify the design as documented?” (It was expected that each team would also produce a tri-fold (or equivalent) presentation poster to be displayed along with the project hardware at the exhibition.)

The report score is determined as a weighted sum of sub-scores for the Title Page, the Project Summary, the Introduction, the description of the Design Requirements, the Design Details, the Outcome of the project, the list of references, the source code, and appendices.

The score for each sub-element is based on a five-point scale, where:

- 1 = Unacceptable
- 2 = Needs significant improvement
- 3 = Acceptable
- 4 = Good
- 5 = Excellent

Table 4-1 summarizes the results from Fall 2010. Eighty-seven percent of the projects (20/23) were at a level of Acceptable or higher for the overall project score. The projects that received less than Acceptable as an overall rating earned a lower rating primarily because they did not function during the exhibition and were not implemented well. All of the projects (100%) demonstrated at least Acceptable quality in the design concept. Ninety-one percent (21/23) projects were Acceptable or better in terms of the team being able to articulate the design requirements in the report for the mechatronic system that they designed. Ninety-six percent of the project reports earned Acceptable or better rating for the documentation of the details of their design. To ensure that each person on each team is achieving this outcome, a peer evaluation is performed, which is worth 10% of the final grade. Three of the 23 teams in Fall 2010 had

problems with one individual each. This peer evaluation is discussed in greater details under Outcome 3d.

Table 4-1. Summary of term project scoring for ME 106 Fall 2010. The table shows the results of scoring the sub-elements of the project and the results for sub-scores for the project report.

Statistic	Concept	Implem	Perf	Title	Sum.	Intro	Des Reqs	Details	Out-come	Ref	Source	Apndix	Poster	Ave
avg=	3.83	3.65	3.59	3.72	3.59	3.26	3.35	3.52	3.52	3.15	3.83	3.43	3.89	3.66
stdev=	0.44	0.46	0.60	0.47	0.72	0.72	0.70	0.55	0.68	1.21	0.32	0.73	0.37	0.39
max=	5	4	4	5	4	4	4	5	4	4	4	4	4	4.16
nonzero min=	3	2.5	2	3	1	1	1	2.5	1	1	3	1	2.5	2.69
count at or above Acceptable	23	21	21	23	21	19	21	22	22	18	23	21	22	20
% at or above Acceptable =	100%	91%	91%	100%	91%	83%	91%	96%	96%	78%	100%	91%	96%	87%
# below Acceptable =	0	2	2	0	2	4	2	1	1	5	0	2	1	3
% below Acceptable =	0%	9%	9%	0%	9%	17%	9%	4%	4%	22%	0%	9%	4%	13%

ME 195a Senior Design Project

The senior design project is a two-semester culminating design sequence. Four sections are offered each semester, and all data presented are for all four sections. The data in Table 4-4 are based on analysis of the first semester team project reports. All instructors in the four sections emphasize the need for clarity in Items 1, 2 and 4 to their students, and these items must be clearly defined and described in the project proposal submitted by each design team at the very beginning of ME 195A in the Fall semester. Students are taught to develop their thoughts on Items 3 and 6, and they are presented to section instructors, usually in the second or third individual session into the semester. Examples of project types and some external constraints are given in Table 4-5 for one section of the course in Fall 2010. Information for other sections are given in the course binder.

Outcome 3c Conclusions

The results of these courses show that this outcome is strongly met. No further analysis is needed except for ME 195b results showing the culmination of their senior design process.

Outcome 3d -- an ability to function on multi-disciplinary teams

ME graduates:

1. Participate in team discussion, respect team members opinions, resolve conflicts (if any), and make group decisions
2. Demonstrate team leadership by taking responsibility for various tasks, motivating others to reach project goals

3. Communicate ideas relating to ME in layman's terms that others outside the discipline can understand

Table 4-4 Outcome 3c results from ME 195a. Results are given as percentage of students achieving scores in a given range.

Outcome 3c – 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			
	Good to Excellent (Score 4 to 5)	Acceptable (3)	Lacking to Poor (1 to 2)
1. Clearly define design problem statement	96	4	0
2. Generate several concepts and select best concept	93	7	0
3. Develop design specifications (including materials, geometry, operating parameters)	59.74	22.38	17.88
4. Perform engineering analyses (FEA or analytical methods)	100	0	0
5. Perform design verification with prototype or simulation	N/A in ME 195A		
6. Show evidence of considering external constraints	79.5	20.5	0

Add spring 11 data

Students work in teams in many classes. For assessment purposes, analysis of ME 106 as well as the senior design sequence are shown here. Teamwork is explicitly taught and discussed in Engr 10 Introduction to Engineering, and students do outside reading for ME 195a/b Senior Design Project.

ME 106 Fundamentals of Mechatronics

Students in ME 106 work in pairs to do the laboratory exercises, and teams of two to five to do the term project. For the laboratory exercises there is much give and take and mixing in terms of tasks (circuit construction, programming, and debugging). In the term project, there tends to be more compartmentalization by team members, but the project involves multiple disciplines such as mechanical design and fabrication, electrical design and fabrication, programming, testing, and documentation of the design.

Implemented Improvement: Every student must evaluate his or her team mates in terms of their individual performance on the project. Following up recommendations from the Spring 2010 assessment, the individual performance ratings were separated from the term project score and made to stand alone as 10% of the course grade.

The quality of the project outcomes seems to indicate that the students in ME 106 do have an ability to function on multidisciplinary teams (86% of the teams received Acceptable or better on the project report (mean=3.66, s=0.39, N=23 projects). This is similar to Fall 2007 assessment data which showed 89% receiving a C- or better.

Only three of the 23 teams in spring 2010 acknowledged issues through the Individual Performance evaluation with one team member (almost exclusively due to lack of effort, and for one team, lack of collegiality).

The results from the Term Project and Individual Performance evaluation suggest that Outcome 3d is being met.

ME 195a Senior Design Project

This is a terminal design class for mechanical engineering students. As such, we define multi-disciplinary teams to be members in the same team working on various sub-mechanical engineering disciplines such as: thermal/fluids, rigid-body dynamics, and mechatronics that include dynamics and control, sensors and actuators and electronics control circuit design, etc. There are projects that require synergistic integration of electromechanical systems, e.g., in vehicle design and prototype constructions, as well as mechanical/chemical interactions. Students from inter-engineering disciplines would work together in teams. Examples of latter cases were design project involving students from ME and EE majors working together on projects on energy-efficient electric vehicles with regenerative braking energy systems. There are also ME students who have joined Aerospace engineering majors in space-related projects. Projects and student involvement vary from year to year. However, almost all projects are multidisciplinary within mechanical engineering according to our definition, and some include students from other majors/disciplines as well. As an example, project topics and makeup in one section of the course in 2010-2011 is given in Table 4-5. Information for other sections is given in the project binder.

An individual performance evaluation was performed by the students at the end of the semester. Each student evaluated the performance of each team member in ten areas, as shown on the example form shown in Figure 4-3. Questions 3 and 5 relate to PEC 1, questions 1, 2, 7, and 8 to PEC 2, and question 10 to PEC 3. For PEC 1 and 2, 6% of students received unacceptable scores in Fall 2010, and for PEC 3, 4% received unacceptable scores. Overall these results indicate that the teams worked well together in all areas with the exception of one team in one section with significant problems to overcome. The instructor is working with this team.

Outcome 3d Conclusions

Data from projects in ME 106 and 154 illustrate that most teams work well together. Scores from the peer evaluation form indicate that each PEC is being met. In addition, an alumni survey showed that 82% of graduates felt that SJSU provided them with a strong background in interpersonal, team, and leadership skills. As a future improvement, teamwork could be more explicitly introduced in this course. However, recommended improvements to Outcome 3f in this course are more urgent and will be implemented first, since data show that the teams are working well in all areas.

Outcome 3e -- an ability to identify, formulate and solve engineering problems

ME graduates:

1. Define and articulate the problem in engineering terms
2. Research and collect information pertaining to the problem
3. Develop a plan to tackle the problem

4. Draw on the pertinent subject knowledge/information and assess the accuracy of that information

5. Monitor their problem solving process, reflect on its effectiveness, and modify the process as needed

Table 4-5 Project topics and team makeup in one section of ME 195a/b in Fall 2010

Proj · No.	Title	No. of ME Student	Objectives	Science/ Engineering Disciplines	Environ- mental Constraints
1	Wind deflector for rooftop wind power generations	4	Design the field testing using SJSU developed wind deflector to mitigate and control turbulent wind flow over rooftop of high rise buildings in urban centers. The chosen site is the rooftop of Duncan Hall on campus.	Team also includes 2 faculty & 2 students from meteorology dept. and ME involving CFD, CAD and wind resource measurements.	100% on clean renewable energy development
2	SJSU-regenerative braking system (RBS) for electric vehicles	5	To retrofit the regenerative braking system (RBS) developed at SJSU for GEM electric vehicle	One faculty and 3 students from EE joined ME faculty and students. Involves CAD, FEA, mechatronics	100% on energy efficient & emission-free vehicle design
3	SJSU-RBS for hybrid electric vehicle	3	To retrofit the SJSU-RBS to Honda Civic hybrid electric vehicle	ME involving CAD, FEA and mechatronics	70% on energy efficient & emission-free vehicle design
4	SJSU-RBS for hybrid electric vehicle	6	To retrofit the SJSU-RBS to Toyota Prius hybrid electric vehicles	ME involving CAD, FEA and mechatronics	50% on energy efficient & emission-free vehicle design
5	Energy-efficient HVAC for Royce Hall on campus	4	To design a new energy-efficient HVAC system for an old dormitory, the Royce Hall on campus	ME involving thermofluids, design, CAD	100% on building energy efficiency
6	Energy-efficient water supply, conservation and recycling for Royce Hall on campus	5	To design a new energy-efficient hot & cold water supply system and recycling of grey water for an old dormitory, the Royce Hall on campus	ME involving thermofluids, design, CAD	100% on building energy efficiency

ME 195 Individual Performance Evaluation

(adapted from <http://pr.ernu.edu/~whetten/classes/standards/team-eval.html>,
http://uhrm.uchicago.edu/forms/pdfs/emp_perf_eval.pdf, and <http://www.engr.sjsu.edu/nikos/courses/engr10/teamcard.htm>)

Part of your semester grade will be based on your individual performance as evaluated by you and your team members. Using your best, *objective* and *fair* professional analysis, complete the following evaluation form concerning your and your team members' performance over the semester. For the questions below, rate yourself and your team members using this scale:

- 1 = poor (unacceptable performance)
- 2 = fair (marginally acceptable performance)
- 3 = average (acceptable performance)
- 4 = good (often exceeds acceptable performance)
- 5 = excellent (truly superior performance)

Your Name: _____ (Y)

Member 2 - Name: _____ (2)

Member 3 - Name: _____ (3)

Member 4 - Name: _____ (4)

Member 5 - Name: _____ (5)

1. <u>QUALITY of work on the project</u> : done correctly, clearly, completely, attention to detail, recommends innovative solutions, seeks to continually improve work	5	2	5	5	5
2. <u>QUANTITY of work on the project</u> : delivered on responsibilities, worked efficiently and in an organized manner	4	1	5	5	5
3. <u>Level of COMMITMENT given to the project/team</u> : attended all meetings, came on time, was prepared and ready to work, was dependable and reliable.	4	1	5	5	4
4. <u>Demonstration of JOB KNOWLEDGE</u> : understanding of project goals and tasks required to reach goals, applied appropriate knowledge and skills to accomplish tasks	5	2	5	5	5
5. <u>Ability to COOPERATE</u> : accepts guidance willingly, works constructively with others on the team, 'team player' rather than 'lone ranger'	5	4	5	5	5
6. <u>Demonstration of JUDGMENT</u> : identified and analyzed problems, developed effective solutions, managed time effectively, effectively prioritized work tasks	5	2	5	5	5
7. <u>ATTITUDE toward work on the project</u> : positive, encourages others, seeks consensus	5	3	5	5	5
8. <u>INITIATIVE taken on the project</u> : proactive, does not wait to be told what to do	4	1	5	5	5
9. <u>ADAPABILITY</u> : ability to handle changes to job assignment, schedule, work environment	5	2	5	5	5
10. <u>COMMUNICATION skill</u> : clear oral and written communication	5	3	5	5	5
Totals=	47	21	50	50	49
Average (divide total by 10)=	4.7	2.1	5	5	4.9

Additional Comments (use the back if necessary):

Team member 5: Name: _____ Comments: Gave great guidance & tips with his industry experience. (5)

Team member 4: Name: _____ Comments: showed little effort throughout semester, but took on responsibilities VERY LATE in semester. (4)

Team member 3: Name: _____ Comments: Well organized. Needed no supervision and always delivered quality work. (3)

Team member 2: Name: _____ Comments: Knowledge of CAD programs was good asset to team. Very enthusiastic about project. (2)

Self - Comments: _____ (Y)

Signature of evaluator Robert Berger Date 12-10-2010

Figure 4-3 Example Individual Performance Evaluation form from Fall 2010

Problem-solving methodology is addressed in many courses throughout the curriculum. To assess this outcome, analysis of open-ended problems in three courses has been performed.

ME 111 Fluid Dynamics

In one open-ended assignment, students are asked to decide whether they would get less wet during a rainy day if they (a) walked to their destination, or (b) ran to their destination. They are required to make assumptions, model and evaluate the problem, and come to a conclusion. This assignment was only assigned in one of the two sections in Fall 2010. A summary of student scores are below:

Mean: 19.1/25
Standard Deviation: 3.36
Students > 70%: 45
% Students > 70%: 76%

Because it is open-ended and requires students to chart their own course to the solution, it provides evidence that Outcome 3e is being met through this assignment. Unfortunately, it was only assigned in one section in Fall 2010. Although the benchmark is marginally met in this section (76% of students scored 70% or above), the fact that the second section did not assign it indicates that half of the student population did not benefit from the instruction. For the future, all sections of ME 111 will be required to assign either this problem or another open-ended problem.

ME 106 Fundamentals of Mechatronics

There are many elements in ME 106 where students are challenged to identify, formulate, and solve engineering problems. The term project, mini-project, and the lab exercises (in that order) are the most significant elements contributing to this outcome. The term project has been discussed above, and the observations from Outcome 3c apply to Outcome 3e. The lab exercises often require the students to debug hardware and software problems that crop up in the course of the lab session. The mini-project is an extended homework assignment, where students must integrate what they have learned to design a mechatronic system where a potentiometer is used to control the speed of a dc motor. The mini-project presents a list of design requirements, and the students must develop a hardware schematic and the software to control both speed and direction of the motor. The grade record from Fall 2010 shows that 98% of the students with non-zero scores for the assignment (N=50) achieved above 69% (C- level) on the mini-project. The remaining eight students earned zero scores either for failure to turn in the assignment (N=3) or for submitting identical copies of the assignment (N=5), but two of these students will be repeating the course, giving a total of 87% of passing students receiving a C- or better. It appears that Outcome 3e is being well-addressed by ME 106, and no improvements are suggested at this time.

ME 154 Mechanical Engineering Design

The term project in ME 154 likewise is open-ended, where students define their own problems and follow them through to evaluation of their chosen solution method. This project is discussed under Outcome 3c, and many of the same conclusions apply to Outcome 3e.

Outcome 3e Conclusions

The open-ended projects in ME 106, ME 154 (as well as ME 195a/b) illustrate that students are able to identify, formulate, and solve engineering problems, particularly since these projects are not defined by the instructor but rather are chosen by the students themselves. To show that students are able to solve more analytical problems, the open-ended problem in ME 111 will be assigned in all sections in the future. The course coordinator for ME 111 will ensure that all instructors understand that this problem (or one similar) must be included in every section every semester. Also supporting this outcome is the alumni survey which shows that 96% of respondents felt that SJSU provided a good foundation in skills to find information and learn on their own.

Outcome 3f -- an understanding of professional and ethical responsibility

ME graduates:

1. Demonstrate knowledge of a professional code of ethics
2. Demonstrate an understanding of the impact of the profession or work products on society and the environment
3. Demonstrate professional quality in project performance, punctuality, collegiality (teamwork), and service (volunteer) to the ME profession.

This outcome is taught in Engr 10 Introduction to Engineering, where four lectures on the topic are included, and ME 195a/b Senior Design Process. In addition, plagiarism is discussed in detail in Engr 100W Engineering Reports and other classes.

Engr 10 Introduction to Engineering

Typically only students who start at SJSU as freshman take this course. For transfer students, only courses that include an ethics component are given equivalency to Engr 10. Most students who come without a course equivalent to Engr 10 take Engr 11, a one-unit introductory course for transfer students that includes the same ethics component as Engr 10. One course learning objective in Engr 10 relates specifically to ethics: "Use ethical reasoning to address to evaluate ethical dilemmas."

This class includes four lectures relating to a variety of ethical issues, and students examine and discuss several case studies in class. Examples of homework assignments based on two of these case studies are included in the outcome binder. Exact assignments and case studies chosen vary from semester to semester. They also must answer questions relating to ethics on the final exam. Instructors set a performance goal of 80% of students receiving a 70% or better, which was achieved in the Fall 2010 data presented here. The percentage correct for the five questions on the final exam were 86%, 94%, 86%, 12%, and 95%. However, subsequent analysis showed that the question receiving only 12% correct answers was worded poorly and was thrown out.

ME 195a/b Senior Design Project

There are three assignments relating to ethics in ME 195A&B:

- (1) Students are instructed to read the ASME Code of Ethics online in ME 195A. A special session on student's learning of this document will be held in ME 195B in Spring 2011. There will be open discussion and a short quiz on their learning of this document.

(2) A quiz on what the students had learned from two video documentaries: “Professional Ethics” produced by the Duke University sponsored by the NSF, and “Blowing whistles” was performed.

(3) Instructors require students to become aware of the ethic issues and the impact of their projects on society and environment and discuss them in their team projects.

Results of assessment for all four sections are provided in Table 4-6.

Table 4-6 Outcome 3f data for ME 195a/b

Outcome 3f – An understanding of professional and ethical responsibility			
	Good to Excellent (Score 4 to 5)	Acceptable (3)	Lacking to Poor (1 to 2)
1. Read ASME code of ethics (include it in ME195B if not in ME195A)	for ME 195B only		
2. Attend Ethics seminar and take quiz (use quiz score)	100	0	0
3. Demonstrate an understanding of the impact of their design product (senior project) on society and/or environment	100	0	0

The third performance criterion is emphasized by all faculty in all courses in their requirements of timely, professional submissions for all assignments. In addition, the professional quality of student projects is illustrated by the large number of awards received in professional organization competitions (ASME, SAE), as discussed under Outcome 3i.

Outcome 3f Conclusions

This outcome appears to be marginally achieved through Engr 10 and ME 195a/b. The quiz required of the students in ME 195a requires a limited depth of understanding of ethical issues, and the instructors have indicated that they do not believe that they have sufficient time to go into this subject in depth in their courses. As a result, an ethics module be incorporated in the three capstone courses rather than the senior project sequence. Each student must take one of the three capstone courses (ME 157, 182, or 190) to graduate. The alumni survey results support these conclusions. A total of 71.4% of respondents felt that SJSU gave them a strong foundation to understand ethical choices inherent in the engineering profession to provide for issues of public safety, product liability, and respect for intellectual property. So obviously they are being educated in this area, but it could be stronger.

Additionally, in the past transfer students were allowed to take an extra elective in lieu of Engr 10. This substitution was offered to students through Spring 2010. Starting in Fall 2010 all incoming students have been told to take Engr 10 or 11 so that they do not miss this ethics content. However, we must honor the substitution offered to students who began prior to Fall 2010, and thus we still have students who miss the ethics content in Engr 10.

Outcome 3g -- an ability to communicate effectively

ME graduates:

1. Produce well-organized reports, use clear and correct language and terminology when describing experiments, projects, or solutions to engineering problems.
2. Give well-organized presentations, use visuals to convey their message effectively and stay within their allotted time.

Students write reports in many classes and give oral presentations in multiple classes. For assessment purposes, ME 115, ME 120, and Engr 100W are discussed here. Report-writing is explicitly taught in ME 115, 120, and Engr 100W, and extensive feedback is given to students. The same report format is required for both ME 115 and 120.

ME 115 Thermal Engineering Laboratory

The assignment used to assess if there is evidence that students can communicate effectively is a heat exchanger laboratory where a cross-flow heat exchanger is characterized using the LMTD and effectiveness-NTU methods. Students are required to present technical concepts and information effectively using visual representations such as engineering drawings and data plots. In Fall 2010, the student work sample received was very comprehensive with sections for Abstract, Theory, Experimental Setup, Results, Discussion, Conclusions, References, and an Appendix. The writing appeared to be clear, well-organized, and well-formatted. All equations were typed using Equation Editor, and figures looked professional. In Fall 2010, 100 % of student teams received a C- or better in all three sections offered. This meets the benchmark criterion, although it would be helpful for students to fill out a peer evaluation to show that each individual in the team has achieved acceptable performance.

ME 120 Experimental Methods

Each student in this class presents an individual presentation based on their term project. Data from the instructor's grade record of ME 120 in Spring 2010 shows that no students scored less than 8.9 out of 10 for their individual oral presentation. Similar results were achieved in Fall 2010. These results are very positive and seem to indicate that Outcome 3g (for oral communication) is being met effectively by ME 120. For this outcome, the scoring rubric, for the most part, had enough specific criteria to assess the ability of the students to communicate effectively.

In terms of written communication, each student must write individual lab reports for each of six laboratory experiments, which are performed in teams throughout the semester. The first report is edited by the instructor in great detail, looking at everything from technical content to proper organization, grammar, and spelling. Each student has an individual conference with the instructor to go over this first report, and students are expected to implement the improvements that they have learned in subsequent reports. The grade record shows that 100% of the students scored better than 70% (C-) on each of the six laboratory reports.

Engr 100W Engineering Reports

Engr 100W is the technical writing class required of all engineering majors. Students must pass the Writing Skills Test, graded by outside evaluators, before enrolling in ENGR 100W. This test is required for all students in the CSU system. Scores are 0 –12. Students who receive a 6 or

higher may enroll in ENGR 100W. The student learning objectives for this course are listed below.

Learning Objective 1: Students shall be able to organize and develop essays and documents for both professional and general audiences, including appropriate editorial standards for citing primary and secondary sources.

Learning Objective 2: Students will be able to distinguish science from pseudo-science.

Learning Objective 3: Students technical writing skills shall improve throughout ENGR 100W. [Students shall be able to refine the competencies established in Written Communication IA and IB.]

At the end of ENGR 100W, students must pass the Writing Evaluation Exit Exam, also graded by outside evaluators, with a score of 7 or higher. Professional evaluators grade the ENGR 100W Writing Evaluation Exit Exams and assess them based on features such as organization, clarity, consistency of point of view, cohesiveness, appropriateness of diction and syntax, correctness of mechanics and usage, and content with appropriate details to support a thesis or illustrate ideas. Scores are 0 –12. Students who receive a 6 or less must be given a No Credit in the course.

Implemented Improvement: Based on Exit Exam scores from the last two years, the E100W team identified a weakness in student writing. This oversight was related to students supplying insufficient details to fully support their ideas put forth in a document. Throughout Fall 2009, the E100W team worked on this with students and then created prompts for the Exit Exam that would test if students had mastered this important writing skill. The results were quite gratifying, with large improvements in scores on the Exit Exam. Comparing their WST essay scores to their Exit Exam scores, there was an overall average gain of 1.14...meaning a 7 moved up to an 8, and an 8 to a 9, etc. There were fewer 6's and 7's. Eleven students earned an 11, which is an exceptional score. Direct Measurement of student learning objectives was performed, as shown in Table 4-7.

Table 4-7 Assignment assessment relating to Student Learning Objectives in Engr 100W

1. SLO 1	Properly addressing their audience <u>and</u> using proper documentation: Audience Memo lab – 97% passed with a score of 80% or higher. Technical Proposal--95% passed with a score of 70% or higher. Persuasive professional formal letter--90% of the students met this. Technical instructions--85% of the students met this.
2. SLO 2	Pseudoscience lab – 97% passed with a score of 70% or higher Journal Article Analysis – 88% passed with a score of 70% or higher.
3. SLO 3	Interview with a Professional Engineer assignment - 100% passed with a score of 80% or higher. Memo-BART Extension (in-class follow-up to speaker)--95% passed with a score of 70% or higher.

From the Fall 2009 Assessment Journal:

Planned: With the campus furlough program in effect, we switched our Friday Environmental Speaker Series to Wednesday mornings. All E100W students are required to attend. Implemented: This was implemented and attendance was slightly higher than the 8:30 am time slot of previous semesters.

Planned: For Spring 2010, class sizes were limited to 20 students, instead of the usual 25. Implemented: This was implemented and provided more one-on-one time in the lab, and more instructor time for feedback. One drawback was less discussion in class. There were fewer students and less diversity.

Overall Comments

We followed through with faculty discussions and found 100% of the ENGR100W instructors still agree:

- We continue to feel that, with 11,000 words required, students received ample assignments.
- On these 11,000 words, every instructor provided detailed feedback.
- We had a workshop last year on developing and using rubrics, and we found that although they save teacher time, they are not as effective for the students. Rubrics are too general, and the extra red ink with explanations is more specific and personal. We found this to be accurate for the Spring 2010 semester. Two instructors used a combination of rubric and marking errors plus margin comments.
- We also found that exploring and answering questions about the earth and environment provides more practice, more research and reading, and more organization of thought. This transfers to better student comprehension of the material and, ultimately, better skills and scores on the Exit Exam. The exit exam content continues to improve.

When comparing student Writing Skill Test scores (taken before enrollment in ENGR 100W) with their Exit Exam scores (graded on a scale of 0-12), the average score went up 1.02.

Outcome 3g Conclusions

The exit exam for Engr 100W ensures a minimum writing competency for each student, as well as the requirement that students pass the Writing Skills Test prior to enrollment. Evaluation of student learning objectives also shows a strong achievement of this outcome in Engr 100W. ME 115 and ME 120 give students experience writing engineering laboratory reports, and the data analyzed here indicate that this outcome is being achieved. Additionally, alumni surveys showed that 93% of respondents felt that SJSU gave them a strong background in communication skills and 89% in interpersonal, team, and leadership skills.

Outcome 3h -- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

ME graduates:

1. Take into consideration the environmental impact when designing an engineering product.
2. Take into consideration the health/safety (societal) impact when designing an engineering product.

3. Demonstrate understanding on the environmental/health/safety and economic tradeoffs (cost analysis) of engineering products, including those they design in course projects.
4. Identify global contemporary problems that involve ME

Throughout the curriculum, instructors attempt to show students the “big picture” by incorporating current environmental problems, economic considerations, and global viewpoints in classes. This outcome is assessed using two courses, ME 113 Thermodynamics and more importantly in the senior design sequence.

ME 113 Thermodynamics

The assignment given in this area changes from semester to semester to prevent student copying and based on instructor preference. The two commonly used assignments are discussed here.

In Spring 2009, the ME113 Thermodynamics course was assessed related to this outcome. An assignment on global impact and contemporary issues of thermodynamics was incorporated in this required course. The objectives of this assignment are to investigate some of the global impacts and contemporary issues that result from thermodynamic engineering solutions and to tie some of the theoretical concepts discussed in class to consequences and events that can affect citizens personally. This assignment is performed in group of two to three students, and each group delivers a report based on at least three articles from popular journals and legitimate magazines. The report includes descriptive title, research objectives, background of the selected topics, narrative of the report with discussion and conclusions in detail. Rubrics for grading this assignment was established and maximum of 50 points were assigned as part of the course grade.

Two sections of the ME113 were offered in the Spring 2009. In Section 1 of ME113 for this assignment, 22 out of 31 students (71% of the class) scored a minimum of C-, and majority of these 22 students earned an A or A- in the global impacts report. Section 2 assignment data was not collected for assessment. However, the data would be expected comparable to those in Section 1.

When this assignment is not given, students instead are given the assignment to write a one-page well-researched advocacy memo to convince the governor of California whether or not carbon-dioxide emissions should be regulated. Students were not graded on their choice but rather on how convincing was their argument and the quality of their research as well as how they balanced pros and cons – for example, potential short-term economic harm versus environmental gain.

In Spring 2007, assessment data showed that 65% of students received a C- or better on this assignment. In Spring 2010, this assignment was part of a regular weekly assignment. Students were allowed to skip two of their eleven assignments, and since this was a large assignment near the end of the semester, many chose to skip the assignment (41 out of 72 students--57%). As an improvement, in Fall 2010 this memo was made a separately graded assignment that could not be skipped without penalty. In Fall 2010 25/113 skipped the assignment, and an additional three students did not write acceptable memos. This left 75% with acceptable memos. Memos that were turned in were quite good, and they were submitted using turnitin.com to prevent

plagiarism. When only students who passed the class are assessed, the percentage with acceptable memos rose to 82%.

Therefore, this outcome is marginally acceptable using ME 113 alone. Scores show improvement. To get a larger percentage of students to turn this memo in, it will be placed earlier in the semester in a week with a smaller regular assignment due, and it will be turned into a “Gateway assignment” – one which students must pass with a C- or better to pass the course.

Add Spring 2011 data

ME 195a/b Senior Design Project

In ME195B Senior Design Project in Spring 2009, students in this class were required to attend a seminar on “Globalization and Social Issues in Electronics Manufacturing” offered by Dr. Uri Kogan, Program Manager of the Sustainable Supply Chain Operation of the Hewlett Packard Company in Palo Alto, CA. About 100 students enrolled in this class in four separate sections took the quiz on the subject seminar with questions set by the invited speaker.

In section 1, 100% of the students scored 70% or higher (C-) in the quiz, in section 2, 90.5% of the students scored 70% or higher, in section 3, 85% of the students scored 70% or higher, and in section 4, 83% of the students scored 70% or higher marks. A seminar on globalization is offered every year, although the speaker and exact topic can vary from year to year.

The four instructors of the ME 195 classes in Fall 2010 had specializations in green technologies, energy, mechanical systems design, and robotics and control. Almost all projects in one section and a few other projects in a second were related to environment/health/safety issues. Students are also required to include economics and global perspectives in their design projects. **(how is this done? Depth?)** A special seminar on economics is offered in ME 195A, and two other seminars on “Energy and environment” and “Global economy” are offered to the class in ME 195B. Students awareness of these topics listed under this outcome were strong in Fall 2010 as illustrated in Table 4-8, and two additional seminars on energy, environment and global economics are given in the ME 195b, the second semester of the senior design sequence.

Table 4-8 Outcome 3h results from ME 195a semester reports

Outcome 3h – the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, AND societal context			
	Good to Excellent (Score 4 to 5)	Acceptable (3)	Lacking to Poor (1 to 2)
1. Include environmental impact discussion in final report	83.15	13.6	3.25
2. Include society (related to health or safety or quality of life) impact discussion in final report	84	16	0
3. Understand environment/health/safety and economic tradeoff (cost analysis) and include discussion in final report	82.2	14.55	3.25
4. Identify global contemporary issue related to their senior project in final report	75.66	21.09	3.25

Outcome 3h Conclusions

Although this outcome does not receive significant attention throughout the curriculum, this outcome is met through ME 113 and ME 195a/b. Establishing the ME 113 assignment as a “Gateway” assignment in Spring 2011 will improve the achievement of this outcome. The alumni surveys support this conclusion. A total of 79% of respondents felt that SJSU provided them with a broad knowledge and understanding of societal and global perspectives in engineering. This indicates that they do receive pertinent education in this area, but it is not a strong focus of the program.

Outcome 3i -- a recognition of the need for, and an ability to engage in, life-long learning

Recognition of the need for life-long learning: ME graduates:

1. Are willing and able to learn new material on their own.
2. Read articles / books outside of class materials.
3. Continue their education by attending student club meeting, campus workshops, seminars, conferences or plan to go graduate school upon graduation.

An ability to engage in life-long learning:

1. Can access information effectively and efficiently from a variety of sources.

This outcome is a difficult one to assess. Many SJSU students are involved with student clubs, with active chapters of the Association of Facilities Engineers, American Society of Mechanical Engineers (78 members Fall 2010), Society of Automotive Engineers (SAE), Formula SAE (30 members Fall 2010), American Society of Heating, Refrigerating, and Air Conditioning Engineers, Project Enable, Formula Hybrid, and Pi Tau Sigma (112 members Fall 2010) as well as more interdisciplinary groups such as the Society of Women Engineers and Society of Latino Engineers and Scientists. Students have been very active in competitions, winning awards recent years in competitions in Formula Hybrid and SAE as well as receiving more awards than any other universities in the regional ASME competitions. Since the last ABET visit, students received an average of five awards every year in the regional ASME competition (schools are only allowed a maximum of seven entries). In 2010 SJSU ME students received 2nd place nationally for the Hybrid-in-Progress category and 12th overall. In 2009 the FSAE team won Rookie of the Year at Formula SAE West. A recent survey of graduates one to five years out of school showed that 35% had attended an MS or MBA program full- or part-time, and the same percentage had been enrolled in certificate programs or other part-time training. Forty-five percent were current members of professional societies, and the same percentage had passed the Fundamentals of Engineering Exam (typically taken their senior year).

Add survey data from ME 195b

The high number of student awards in these competitions illustrate the students’ willingness and ability to learn material on their own, and the large number of students involved in the clubs show the students’ desire to expand their horizons beyond the classroom.

To assess the ability to engage in life-long learning via the ability to access information effectively and efficiently from a variety of sources, a small research project from ME 111 Fluid Dynamics was assessed as well as a project in Engr 100W Engineering Reports.

ME 111 Fluid Dynamics

The ME 111 project is assigned at the end of the course, asking students to research any application of fluid mechanics to a contemporary application. They work in groups of 3-5 comprised of mechanical and civil engineering majors. Requirements of the assignment include: finding relevant articles written within the past 10 years from the SJSU library databases and other sources, writing a joint technical research report describing the importance of the contemporary application and the role of fluid mechanics, and delivering an oral presentation to the class on their research project. The topics for this assignment ranged widely with examples such as understanding blowout preventers, the aerodynamics of baseball, levee failure in New Orleans. The student grades and distribution on this assignment for both sections offered in Fall 2010 are summarized below.

S1	S2
Mean: 51.4/60 StDev: 5.00 # Students > 70%: 54 %Students > 70%: 92%	Mean: 84.9/100 StDev: 5.6 # Students > 70%: 62 %Students > 70%: 100%

Engr 100W Engineering Reports

In one assignment in this course, students have to evaluate a very professional-looking website with a cleverly hidden underlying agenda. Class instruction helps students learn how to evaluate information for accuracy and reliability. In Fall 2009, several students redid this assignment after receiving their marks and feedback, and after that 97% of students received a C- or better.

Outcome 3i Conclusions

Data presented supports the conclusion that this outcome is being met. In Spring 2011, a survey will be added to ME 195b to assess PEC 3 in greater detail. In addition, 96.4% of alumni survey respondents indicated that SJSU provided them with the skills to find information and learn on their own.

Outcome 3j -- a knowledge of contemporary issues

ME graduates are able to:

1. Give examples of contemporary issues related to Engineering and Technology, and articulate a problem statement or position statement for each.
- 2 Explain their relevancy to the present time.
- 3 Suggest reasonable/possible theories regarding the root causes of contemporary problems and identify possible solutions to contemporary problems

In many courses, professors pull contemporary issues in to illustrate the application of their coursework. As examples, assignments in ME 11 Fluid Dynamics, ME 113 Thermodynamics, and Engr 100W are assessed.

ME 111 Fluid Dynamics

The assignment used to assess this outcome was the research project discussed under Outcome 3i. This project requires students to give examples of contemporary issues in engineering,

explain their relevancy, suggest root causes and possible solutions. In Fall 2010, 95% of students received a C- or better in one section and 100% in the other. A good range of important contemporary topics were chosen by the students. In a similar assignment in Fall 2007, 88% and 97% of students in the two sections of ME 111 received a C- or better.

ME 113 Thermodynamics

ME 113 was used to show that students have a knowledge of contemporary issues, in particular, global warming and ozone depletion.

After a presentation on the science behind global warming and the reasons for the extensive public debate, students were given the assignment to write a one-page well-researched advocacy memo to convince the governor of California whether or not carbon-dioxide emissions should be regulated. This was discussed in detail under outcome 3h. When only students who passed the class were assessed for Fall 2010, the percentage with acceptable memos was 82%. On the final exam students were also asked to explain how CO₂ is said to “trap” heat in the atmosphere, causing global warming. Only 54% of students were showed a thorough, complete understanding of the phenomena. The lecture for this section will be changed for Spring 2011 to explain common misunderstandings, and the memo is being turned into a “gateway” assignment in Spring 2011, as discussed earlier. During a previous assessment cycle a similar but more extensive global warming paper was assigned with 91% of students receiving a C- or better.

On the final exam in Fall 2010 students were also asked what element in Freon caused ozone depletion, and whether R134a has the same problem. While almost all students knew that chlorine was the cause of ozone depletion in Freon, 36% of students thought that R134a still has some problems with chlorine, which it does not. This point will be emphasized in lecture to a greater degree in the spring.

Engr 100W Engineering Reports

Students in this course always write multiple papers on contemporary issues, often relating to environmental concerns. The topics change from semester to semester. In Spring 2010, for example, a speaker came to discuss the proposed extension of the BART train line. A total of 95% received a score of C- or better.

Outcome 3j Conclusions

While this outcome is not a strong focus of the curriculum, results indicate that it is being achieved to an acceptable level. However, the students’ understanding of the root causes of global warming could be strengthened.

Outcome 3k -- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

ME graduates can:

1. Use modern technology for engineering system design, control, and analysis.
2. Use contemporary software to write technical reports and give oral presentations.
3. Use computer simulations to conduct simple parametric studies and design/process optimization
4. Use modern equipment and instrumentation in their labs.

While modern tools are used in most classes, for assessment purposes we are presenting analysis of assignments in ME 106 Fundamentals of Mechatronics, ME 113 Thermodynamics, ME 115 Thermal Engineering Laboratory, ME 154 Mechanical Engineering Design.

ME 106 Fundamentals of Mechatronics

This course has been described previously under Outcome 3b. Students in ME 106 use modern electronic test and measurement equipment in all individual laboratory exercises and in their term project work. ME 106 makes extensive use of microcontrollers and software development tools that are current and widely used. The scores on the lab reports are perhaps the best measure that addresses Outcome 3k. The grade record from spring 2010 shows that 95% of the students achieved 70% (C-) or better on their lab report scores. It appears that Outcome 3k is also being well-addressed by ME 106, and no improvements are suggested at this time.

ME 113 Thermodynamics

This course has been described previously under Outcome 3a. ME 113 was used to show that students can use computer simulations to conduct simple parametric studies and design/process optimization. In this course, students learn use EES Engineering Equation Solver. This is a simultaneous equation solver with thermophysical properties built in. For one assignment, students develop models of a Rankine cycle with reheat. Students do a very simple optimization problem where they plot cycle efficiency as a function of intermediate pressure. In this way they can choose the intermediate pressure that gives the highest efficiency. In Spring 2010, this assignment was part of a regular weekly assignment. Students were allowed to skip two of their eleven assignments, and since this was a large assignment near the end of the semester, many chose to skip the assignment (41 out of 72 students--57%).

Implemented Improvement: As an improvement, in Fall 2010 this assignment was graded separately and could not be skipped without penalty, and the percentage of students who passed the class who received below a C- on this assignment dropped to 34%. Approximately 2/3 of these students were ones who skipped the assignment.

Because of the large number of students who skipped this assignment, we cannot say that this outcome is met using ME 113, although progress was made from Spring to Fall 2010. In Spring 2011 more EES problems will be assigned so that students are more familiar with the program, and the portion of the final grade devoted to computer modeling will be increased.

ME 115 Thermal Engineering Laboratory

The assignment used to assess if there is evidence that modern tools are used in our instruction is a finite difference computer project. In this individual assignment, students use MS Excel to solve a well-posed system of linear equations to solve a 2D steady conduction problem with non-uniform boundary conditions, resulting from the application of the finite difference technique on the heat conduction equation. The same assignment is given in all sections of the course. In Fall 2010 in one section 92% of students received a C- or better, and 100% received a C- or better in

the other two. The student work samples received were accurate and correct in their derivation, implementation, and solution.

ME 154 Mechanical Engineering Design

This course has been previously described under Outcome 3e. Performance criteria 1, 2, and 4 are evaluated below.

PEC 1: Use modern technology for engineering system design, control, and analysis.

Students were required to complete an Assembly Drawings assignment that required preparing using 3-D computer-aided design software. The assignment was graded by A-F letter grade. 49 of 57 (86%) of students passed with grade of C or higher, 6 students received marginal grades of C-, and 2 students failed to submit the required assignment in Spring 2010. Using a grade of “C-” or better as the threshold, this performance criterion supports that Outcome 3c is met, except for the 2 students in who failed to submit the assignment. There is some concern that more than 10% of the students marginally met the threshold with a “C-” grade. In Fall 2010, this assignment was not assigned, but students used modern CAD software for their design project. Out of 9 groups, 4 groups used SolidWorks, 2 groups used Pro Engineer, 1 group used Autodesk, 1 group used AutoCAD, and the remaining group used a generic CAD program which has not been revealed in their report. All teams received a C- or better on their reports.

Students were also required to complete a Force Analysis assignment that required solving for unknown variables in mechanism dynamics using linear algebra solvers (e.g. matrix inversion). The assignment was graded by A-F letter grade. In Spring 2010, 56 of the 57 (98%) of students passed with grade of “C-” or higher and 1 student failed to submit the required assignment. Using a grade of “C-” or better as the threshold, this performance criterion supports that Outcome 3c is met, except for the 1 student who failed to submit the assignment. A limitation of these assignments as evaluation tools is that they were both team assignments. Teams were typically comprised of 2 to 4 students. So this assignment has inadequate resolution for assuring that every individual meets the outcome. No assignment in this class specifically tested students’ ability to use modern technology for control.

Implemented Improvement: As a result, in Fall 2010 this homework assignment was assigned individually. From that assignment, 76% of the students received 70% (C-) or better in homework score.

PEC 2: Use contemporary software to write technical reports and give oral presentations.

In Spring 2010, students were required to prepare a Project Videos assignment that required presenting their design project as a multimedia DVD. The assignment was graded by A-F letter grade. 55 of 57 (96%) of students passed with grade of C- or higher and 2 students failed to submit the required assignment. In Fall 2010 students used Powerpoint to present their results, and 100% of teams had acceptable performance. In both semester, students used Microsoft Word to write their reports, as in many classes. Using a grade of “C-” or better as the threshold, this performance criterion supports that Outcome 3c is met, except for the 2 students who failed to submit the assignment in Spring 2010. A limitation of this assignment as evaluation tool is that it was a team assignment. Teams were typically comprised of 2 to 4 students. So this assignment has inadequate resolution for assuring that every individual meets the outcome.

PEC 3: Use modern equipment and instrumentation in their labs.

No evaluation tool used in this offering in the course specifically tested this performance criterion. Students were required to fabricate prototypes of their mechanisms, but without mandate to use modern equipment.

Conclusions for Outcome 3k

Results show excellent achievement of this outcome. The sole area of concern is the students' ability to perform simple parametric studies. This should be improved when recommended adjustments in ME 113 are made. Alumni surveys indicate that 79% of respondents felt that they received strong skills to work with computers, performing design, simulation, and data acquisition and processing. Survey responses indicate an interest by alumni in learning specific software programs (tolerancing programs, Flotherm, IcePak, ProE, Solidworks, eQwest, Ansys). It is the goal of our program to provide students with the background to learn new programs but not to introduce them to every program that they may encounter on the job. In recent years, however, weekend short courses have been introduced to introduce students and working professionals to these programs outside of the regular curriculum. A list of short courses offered in 2007-2010 is shown in Figure 4-4.

C. Continuous Improvement

This section is divided into two sections. First, overall program improvements since the last visit are described. Second, individual course improvement that were made based on assessment following the last visit are described.

1. Overall Program Improvements

a) Minimum Grades Required to Graduate

Prior to Fall 2006, the minimum grade required to graduate was a D- in all courses in the major with the exception of a C- in ME 101 Dynamics, ME 111 Fluid Mechanics, and ME 113 Thermodynamics. This left a significant number of students graduating without achieving the minimum acceptable level of achievement in multiple courses, and hence multiple outcomes. To eliminate this problem, the minimum grade required for graduation in all courses in the major was changed to a C- in Fall 2006.

In Fall 2008 the minimum grade in the core classes of CE 99 Statics, CE 112 Mechanics of Materials, ME 101 Dynamics, ME 106 Fundamentals of Mechatronics, ME 111 Fluid Mechanics, and ME 113 Thermodynamics was changed to a C to improve the preparation in key courses. However, this proved too confusing to students and faculty alike, who could not remember which courses required a C and which a C-. Thus, the minimum grade for graduation has been changed back across-the-board to a C- in all courses in the major.

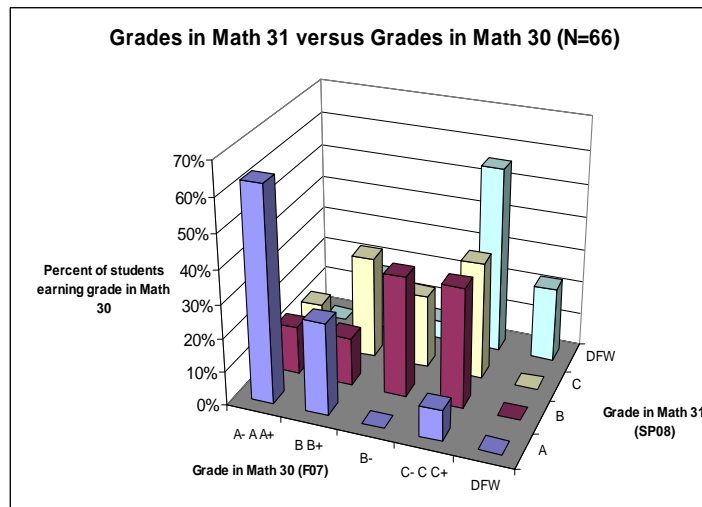
DATES	TITLE/TOPIC
Jul. 28-30, 2010	LabView Basics Training Course
Apr. 9, 2010	Cypress Programmable System-on-Chip (PSoC) Hands-on Workshop
Mar. 29, 2010	LEED Workshop - Green Building Design
Mar. 19, 2010	Strain Gage Workshop
Mar. 13, 2010	Geometric Dimensioning & Tolerancing (GD&T) Workshop
Feb. 27, 2010	Heat Designer Software Workshop
Nov. 21, 2009	Heat Designer Software Workshop
Aug. 12-13, 2009	Basic of LabView & Data Acquisition
Aug. 8, 2009	Solar Energy Systems
Mar. 14, 2009	LabView Basics Workshop
Mar. 14, Apr. 11 & 18, 2009	EIT (FE) Exam Review Sessions in Spring '09
Mar. 7, 2009	MatLab Workshop
Nov. 15, 2008	MatLab Workshop
May 3, 2008	Solar Energy Systems
Apr. 26, 2008	MatLab Workshop
Apr. 19, 2008	Intermediate Pro/Engineer Workshop
Apr. 19, 2008	Flotherm Software Applications Workshop
Apr. 12, 2008	LabView Basics Workshop
Apr. 5, 2008	Autodesk Inventor Workshop
Mar. 15, 2008	Solidworks Workshop
Feb. 23, 2008	Pro/Engineer Workshop
Feb. 14, 2008	Design of Medical Devices with Plastics
Nov. 3, 2007	MatLab Workshop
Oct. 27, 2007	Pro/Engineer Workshop
Oct. 20, 2007	Autodesk Inventor Workshop
Sept. 22, 2007	Solidworks Workshop
May 5, 2007	Pro/Engineer Workshop

Figure 4-4 Short Courses Offered by the MAE Department 2007-2010

A few students are still able to graduate with D's on their record. Students may choose to graduate by the catalog in place when they began their studies at SJSU, and thus any student who began their programs before Fall 2006 are still allowed to have D's on their records. However, for any student starting in Fall 2006 or later, students are required to achieve a higher minimum level of performance than they did prior to the last ABET visit.

b) Minimum Grades for Prerequisites

While the minimum grade required for graduation was changed to a C- in Fall 2006, these minimum grades were not initially put in place for prerequisites. This led to the situation where students could receive a D- in a key course such as CE 99 Statics and then go on to ME 101 Dynamics with plans to retake CE 99 sometime later. As a result, student have taken follow-on courses without a strong background in key pre-requisites, leading to failure or poor performance. As an example, the data in Figure 4-5 show how the performance of students in Math 30 Calculus I at SJSU in Fall 2007 had a direct impact on their performance in Math 31 Calculus II in Spring 2008. Over 50% of students who received lower than a B- in Math 30 received a D or F in Calculus II.



Example: 60% of students who earned A grades in Math 30 also earned A grades in Math 31.
 Example: 56% of students earning a C in Math 30 did not pass Math 31.

Figure 4-5 – Effect of Calculus I grades on Calculus II performance

Clearly, students with stronger backgrounds in the prerequisite course perform better. Thus, to reduce the number of students needing to retake classes, the minimum grade required for all prerequisites has been changed from D- in most cases to a C-. Implementation has been scheduled for Spring 2011 for some courses and Fall 2011 for those remaining. Unfortunately, implementation is too close to the due date of the report to receive sufficient data to assess the effect of this improvement.

c) Accepted course substitutions for Engr 10/11.

Engr 10/11 is one of the courses where we assess Outcome 3f ethics. In the past transfer students were allowed to take an extra elective in lieu of Engr 10 or 11, and thus they missed the ethics instruction offered in this course. This substitution was offered to students through Spring 2010. Starting in Fall 2010 all incoming students have been told to take Engr 10 or 11 so that they do not miss this content. However, we must honor the substitution offered to students who began prior to Fall 2010, and thus we still have students who miss the ethics content in Engr 10.

d) Replacement of CE 113 with ME 41

The Civil and Environmental Engineering Department is phasing out CE 113 Strength of Materials Lab, a 1-unit lab course, starting Fall 2011. In depth discussions were held with faculty in the department to determine in what area students would benefit the most from additional instruction. Additionally, surveys were performed of engineering programs at other schools. The conclusion was that students would benefit from hands-on training on how to safely and effectively use machine shop tools (drills, lathes, etc.). This conclusion was bolstered by the alumni surveys as four respondents out of 31 noted the need for additional training in this area. As a result CE 113 has been replaced with ME/Tech 41 Shop Safety beginning in Fall 2011. A few students have had this course replaced one semester early since the CEE Department was unable to open enough sections of CE 113 in Spring 2011 to accommodate all graduating seniors.

e) ESSC

The Engineering Student Success Center (ESSC) was established several years ago through an external grant to help students move successfully from freshman to senior year, supporting and enhancing their learning and overall academic experience. The center provides outreach and recruitment activities; first-year experience programs for freshmen and incoming transfer students; academic advising by professional and peer advisors, including required advising and workshops for students on probation; assistance with course equivalencies for transfer students; tutoring resources; professional development and practice services; and career and graduate school guidance. Their work has been especially helpful for students on probation (see Criterion 1) and for academic advisors. Their assistance with GE advising and course equivalencies as well as their knowledge of university procedures has been a boon to academic advisors. In addition, the Associate Chair, through the ESSC, has established the MFAT – Master Faculty Advisor Team. This team, consisting of the lead advisor in each program, helps guide, implement, and inform faculty advisors new advising policies and procedures. The presence of this center has resulted in a significant improvement in advising since the last ABET visit.

f) Probation in the Major

The College of Engineering has been struggling with how to deal with low graduation rates and a significant number of students repeating courses. As a result, in Fall 2010 a new Probation in the

Major policy was established. This policy helps students realize when they're having trouble with their major courses early on, to motivate them to improve their performance and to help advisors intervene early. It also helps some students see that engineering major not be the best program for them before their performance has become so bad that they are disqualified from the university. This policy is discussed in Criterion 1, and the text of the policy is given in Appendix E.

2) Course Improvements Made Since the Last Visit Based on Assessment

Each of these improvements have been discussed already in Section B.

Outcome 3a: ME 113 Thermodynamics

Under Outcome 3a, ME 113 was used to show that students can

3. Use science to solve ME problems
4. Use engineering principles (in this case laws of thermodynamics) to solve ME problems.

In previous semesters, some students struggled with basic thermodynamics concepts until the very end of the semester. As a result, two "gateway" quizzes have been installed in the first third of the semester. Students must pass these quizzes to pass the class. Their score the first time they take the quiz is the score that factors into their final grade. These quizzes are given in class. However, if students score below a 75%, they are required to take a new quiz on the same topic online. This quiz can be retaken up to three times. The second quiz focuses on applying the first law of thermodynamics. Of the 113 students in class in Fall 2010, only one student out of 113 failed to pass this quiz after retaking it online. He will have to retake the course. After implementing this change, Exam 1 scores (which is the exam covered by these topics) rose from 65% in Fall 2007 to 70% in Spring 2010 when the first gateway quiz was implemented and 74.5% in Fall 2010 when the second gateway quiz was implemented.

Outcome 3b: ME 120 Experimental Methods

This course is used to show that ME graduates can:

1. Based on an identified problem, design an experiment to acquire data to solve a problem
2. Select appropriate equipment/instrumentation for an experiment to determine/measure the value of dependent variables from the given values of independent variables.
3. Calibrate the instruments from an experimental setup and follow procedures to collect data
4. Perform necessary calculations, error analysis, interpret data, and draw conclusions from a given set of data

Data from the grade record of ME 120 in Spring 2010 shows that no students scored less than 73 out of 100 on their written reports for six directed experiments. These experiments are discussed in more detail in part B. Also, no team scored less than 8.9 out of 10 for their oral presentation or term project report. These results were very positive; however, the scoring rubric did not include specific criteria to assess the students' ability to design and conduct experiments, analyze and interpret data. Thus, it was difficult to provide students with clear feedback about areas where they needed to improve. Therefore, after Spring 2010 it was recommended that the grading rubric be changed to include categories that specifically address:

- Selection of appropriate equipment and instrumentation

- Calibration of instruments
- Comparison of theoretical predictions to empirical results
- Discussion of error sources and error analysis

This recommendation was implemented in Fall 2010, and students received subscores to improve their performance on later lab reports. However, the subscores were not recorded by the instructor, so it was impossible to show conclusively that each performance criteria was being met. Based on recommendations from the Fall 2010 assessment, in Spring 2011 the subscores were recorded. **Add data.**

Outcome 3c: ME 106 Fundamentals of Mechatronics

Based on Spring 2010 assessment data, ME 106 instructors recommended that the project report for the term project clearly articulate the design requirements, especially those that go beyond the basic ones set out by the project guidelines. This change would ensure that each performance criteria under this outcome is addressed by the students in their design process and project reports. Other noted improvements included required documentation of:

- Multiple design concepts
- Description of the method used to arrive at the chosen concept
- Design verification by analysis and testing

As a result of these recommendation, the grade for the project in Fall 2010 was changed to evaluate each element of the design process separately. More explicit instructions were given in the Term Project guidelines for Fall 2010 regarding design specifications and their inclusion as a separate section in the Project Report. The grade for the project is determined as a weighted sum of scores for the following sub-elements: concept, implementation, performance, and report and poster. A complete description of these sub-elements along with results are given in Section B. The report score is determined as a weighted sum of sub-scores for the Title Page, the Project Summary, the Introduction, the description of the Design Requirements, the Design Details, the Outcome of the project, the list of references, the source code, and appendices. Analysis of the data collected in Fall 2010 is presented in detail in Section B.

Outcome 3d: ME 195a

Results of the initial Fall 2010 analysis showed that insufficient data were being collected to show that this outcome was being met. Further data were needed to show if course changes were needed. The assessment has resulted in an improvement in process. For Spring 2011, the following improvements were implemented:

- ME 195a and b students fill out an individual performance assessment survey. The questions on this survey relate to the performance evaluation criteria. Data were collected for each question (rather than a total score as was initially done in Fall 2010). As discussed in Section B, data show that each PEC is being met. Before this improvement in process, there was insufficient data to make this conclusion.

- To increase the training in this area, students have been asked to read the resources available on <http://tlt.its.psu.edu/suggestions/teams/>.

Outcome 3e: ME 111 Fluid Dynamics

As discussed under part B, in one open-ended assignment in this course, students are asked to decide whether they would get less wet during a rainy day if they (a) walked to their destination, or (b) ran to their destination. They are required to make assumptions, model and evaluate the problem, and come to a conclusion. Unfortunately, this project was only assigned in one section (Section 1) in Fall 2010. For the future, the course coordinator for ME 111 will ensure that each instructor will include at least one rigorous open-ended problem or project in this course. Indeed, course coordinators will ensure that every assignment used for assessment purposes is assigned in each section for a given course.

Outcome 3f: ME 195a/b Senior Design Project

Based on the assessment data for the selected courses for the previous ABET visit in 2005, the ME Program satisfied all Student Outcomes except 3f. The outcome satisfaction also indicated that the PEO for the undergraduate ME Program were met except PEO #4 (Considering Ethical Implications) at that time. As a result of our outcomes assessment, the ASME Code of Ethics and discussions on safety, ethics, and liability issues in engineering have been implemented in the ME195A/B courses.

Two “professional ethics” assignments were implemented in the ME195A course in Fall 2006. These were gateway assignments and students were required to perform satisfactorily in order to pass the ME195A course. For those who didn’t do well in the first time were given second chance to re-do the assignment. The end results show that 100% of the students completed satisfactorily in these assignments.

In Fall 2010 the course was reassessed and the students were additionally asked to address ethical issues in their final reports. The details of the assignments related to this outcome are outlined as follows:

(1) Students become familiar with the ASME code of ethics. Students are instructed to read this document online in ME 195A. A special session on student’s learning of this document was held in ME 195B in Spring 2011. There was an open discussion and a short quiz on their learning of this document.

(2) A quiz on what the students had learned from two video documentaries: “Professional ethics” produced by the Duke University sponsored by the NSF, and “Blowing whistles” was administered.

(3) Instructors required students to discuss the ethical issues and the impact of their projects on society and environment in their team projects.

Results of assessment for all four sections are given in Table 4-6 in Section B.

Outcome 3g: Engr 100W Engineering Reports

Based on Fall 2009 assessment results, the Friday Environmental Speaker Series was switched from Fridays to Wednesdays in Spring 2010. All Engr 100W students are required to attend. This was implemented and attendance was slightly higher than the 8:30 am time slot of previous semesters.

Also based on Fall 2009 assessment, for Spring 2010, class sizes were limited to 20 students, instead of the usual 25. This provided more one-on-one time in the lab and more instructor time for feedback. One drawback was less discussion in class. There were fewer students and less diversity.

Outcome 3h: ME 113 Thermodynamics

As discussed earlier, students were given the assignment to write a one-page well-researched advocacy memo to convince the governor of California whether or not carbon emissions should be regulated. In Spring 2010, this assignment was part of a regular weekly assignment. Students were allowed to skip two of their eleven assignments, and since this was a large assignment near the end of the semester, many chose to skip the assignment (41 out of 72 students--57%). As an improvement, in Fall 2010 this memo was made a separately graded assignment that could not be skipped without penalty. In Fall 2010 25/113 skipped the assignment, and an additional three students did not write acceptable memos. This left 75% with acceptable memos. Memos that were turned in were quite good, and they were submitted using turnitin.com to prevent plagiarism. When only students who passed the class are assessed, the percentage with acceptable memos rose to 82%. To increase this number to 100%, this assignment was instituted as a gateway assignment in Spring 2011. Students needed to pass this assignment in order to pass the class.

Outcome 3j: ME 113 Thermodynamics

One improvement related to this outcome is discussed under Outcome 3h. In addition, on the final exam students were also asked to explain how CO₂ is said to “trap” heat in the atmosphere, causing global warming. Only 54% of students showed a thorough, complete understanding of the phenomena. Students were also asked what element in Freon caused ozone depletion, and whether R134a has the same problem. While almost all students knew that chlorine was the cause of ozone depletion in Freon, 36% of students thought that R134a still presents some problems due to chlorine, which it does not. The lectures for these topics were changed for Spring 2011 to explain common misunderstandings, and the importance of the topic of global warming was emphasized to a greater degree.

Outcome 3k: ME 113 Thermodynamics

Assessment of one assignment in this course is used to show that students can use computer simulations to conduct simple parametric studies and design/process optimization. In this course, students learn to use EES Engineering Equation Solver to perform a simple optimization of a Rankine cycle with reheat. In Spring 2010, this assignment was part of a regular weekly assignment. Students were allowed to skip two of their eleven assignments, and since this was a large assignment near the end of the semester, many chose to skip the assignment (41 out of 72

students--57%). As an improvement, in Fall 2010 this assignment was graded separately and could not be skipped without penalty, and the percentage of students who passed the class who received below a C- dropped to 34%. Approximately 2/3 of these students were ones who skipped the assignment.

In Spring 2011, more EES problems were assigned so that students would be more familiar with the program, and the portion of the final grade devoted to computer modeling will be increased. **Add Spring 2011 data.**

Outcome 3k: ME 154 Mechanical Engineering Design

One of the assessed assignments supporting this outcome is a force analysis assignment that required solving for unknown variables in mechanism dynamics using linear algebra solvers (e.g. matrix inversion). This assignment and its results are discussed in Section B. A limitation of these assignments as evaluation tools was that it was a team assignment. As a result, in Fall 2010 this homework assignment was assigned individually. From that assignment, 76% of the students received 70% (C-) or better in homework score.

PEO and Outcome Analysis Summary

The analysis presented here shows that the ME program at SJSU is very strong. The outcome analysis shows that all outcomes are being met. As expected, some outcomes receive greater emphasis in the curriculum than others, and thus those outcomes (such as Outcomes a, b, c, g and k) are met more strongly than others that receive less attention in the curriculum (such as Outcomes f, h, and j). Recommendations have been made to improve performance in those outcomes where the students show weaker performance.

Where the ME program needs to improve is in process. While a good process was established early on, because of some disarray in department administration during the middle years of the 6-year cycle, the schedule of assessment was nearly halted, and the Industrial Advisory Board did not meet and effectively was disbanded. In Fall 2010 regular department administration was reestablished, and procedures set up so a recurrence of the previous department problem will not happen. The original assessment process and schedule has been re-established, and all outcomes have gone through at least one cycle of assessment, improvement, and reassessment. The Industrial Advisory Board met in March 2011, and the members showed strong support for our PEO's. They provided valuable open-ended feedback on the nature of the ideal young engineer that will be used as the first step in possible revision of the PEO's over the next couple years.

While enough data have been received to show achievement of all outcomes, limited external data to validate achievement of the PEO's have been received. One cycle of alumni surveys has been analyzed and has shown good achievement of the PEOs. More importantly, a good schedule for external assessment has been established for the future, with alumni surveys performed every two to three years and the Industrial Advisory Board meeting every year.