Appendix 1.6: College-Level Senior Project Assessment Reports

State of California
M e m o r a n d u m

CAL POLY

San Luis Obispo, CA 93407

To: Erling A. Smith, Ph.D., P.E.
Vice Provost for Programs & Planning

Date: October 19, 2011

From: Mary E. Pedersen, Ph.D.
College of Agriculture, Food and Environmental Sciences

cc Dave Wehner
Bruno Giberti

Subject: **CAFES Summary Report of Direct Assessment of Senior Project for Writing and Critical Thinking**

The academic programs undergoing program review during the 2010-2012 AY conducted direct assessment of senior project for ULOs related to writing and critical thinking. These programs included Agribusiness (AGB), Agricultural Systems Management (ASM), Dairy Science (DSCI) and Horticultural & Crop Science (HCS). All programs involved in this assessment effort sent faculty representatives to the CTL training workshop on assessment of writing using the University Expository Writing Rubric provided in the Fall 2010 for the campus. Each department representative was also engaged in the college-wide CAFES Assessment & Program Review Committee meetings, which met three times per quarter to support department assessment efforts. Faculty experts in writing assessment, use of rubrics, and the norming process met with the CAFES Assessment Committee to provide support for these efforts.

Despite the effort to provide as much training and support for the assessment efforts of the departments, the methods used by each department to collect data and conduct assessment varied so much that it is not reliable to pool the results of the critical thinking and writing assessment from the various programs. The results will be discussed in more general terms. Departments were given the freedom to conduct the assessment in the manner that worked best for the department. The assessment information from the four programs was collected from individual interviews with the department heads and faculty in charge of the departmental assessment efforts, from the SP2 Profile Reports completed (very brief or no data/analysis provided), and one program review document (AGB). The individual department/program reports complied from these sources of data are found on pages 4 – 9 of this document.

<u>Comments on the rubrics including recommendations for improvement.</u>
Two comments were provided on the rubrics. The first comment stated that there was overlap on the critical thinking and writing rubrics. It was recommended to combine them, removing any overlap, and then have only one rubric that would be more likely to be adopted by departments for future assessment efforts. The second comment related to the value of assessing the writing component of senior project since many advisors heavily edit the writing of the projects. The questions then becomes whose writing is really being evaluated, the student's or the faculty's writing.

Method of creating the population of projects and the sample of projects read.

Three different methods were used to sample the population of projects from the programs. Two programs selected all of the senior projects completed in 2010 (ASM, n=14 and DSCI, n=20). Another department collected all the senior projects that had been submitted to the Digital Commons in the library and then removed any projects that had mark ups in the document (AGB, n=9). This sample ended up being a very small number compared to the total senior projects completed that year (~10%) and was considered not representative. The third method involved the department collecting senior projects from faculty from the previous two quarters and then selecting a representative sample of projects from various disciplines in the department (HCS n=8).

Two of the departments (ASM, DSCI) assessed all of the senior projects completed in the year so these were considered very good samples and two of the departments (AGB, HCS) had very small samples that were not considered representative of the populations.

Assessment of senior projects was conducted in various manners by the programs. In two departments, all the faculty were involved in the assessment task (AGB, DSCI). In another department a subcommittee of four faculty conducted the assessment exercise (HCS). In the last program, a English professor was hired to complete the assessment of all the senior projects (ASM).

Results of rubric-based assessments as interpreted by the program.

All programs indicated they observed a lot of variability between how faculty evaluated the same senior projects and between the faculty expectations for the project and level of quality. Many of the programs indicated they need to develop clearer expectations for the components to be included in the final project and a scoring rubric to provide for more consistent grading guidelines. Several programs commented that a lot of the variation between senior projects was influenced by the advising and how much supervision, input and guidance was provided by faculty.

Also the philosophical approach of the faculty regarding the purpose of the senior project was identified by several departments as an issue of concern. Is senior project to be used for an opportunity to teach the student (provide a lot of feedback, correction, editing of writing) or assessment of what the student is capable of performing? The answers to this question would determine the appropriate value of senior project as an assessment artifact.

The assessment of writing and critical thinking skills was considered to be “average” by three of the departments. Agribusiness commented that “few papers were deemed of high quality in terms of the critical thinking and/or writing. There was a lack of consistency in writing styles, a lack of connection between structure of the paper and the topic covered, a general low quality in analytical approaches, a lack of depth and critical evaluation in literature reviews and a general lack of attention to detail in presentation.” (Avg. critical thinking traits 1.72; avg. writing traits 1.78). The Dairy Science program commented that their senior projects demonstrated average critical thinking (2.06) and writing skills (2.05) . Horticulture & Crop Science results indicated “we are in the “emergent” phase for senior projects and assessment of overall learning outcomes.”
(Avg. critical thinking traits 1.63; avg. writing traits 2.05). Only the Agricultural Systems Management program demonstrated good to superior attainment of traits for critical thinking (avg. 3.6) and writing (avg. 3.77). It should be noted that this was the assessment that was conducted by an English professor and the ASM faculty were not involved in the assessment process.

Recommendations for the improvement of senior project policies/procedures at all levels.

Most of the programs noted that senior projects were much more variable and poorer in quality and consistency than was anticipated. There was general agreement that senior projects need significant improvements to help provide more structure and guidelines to improve quality and consistency. Several programs noted they were going to develop scoring rubrics to be used by all the faculty to provide guidelines for the minimum components to be included in senior projects as well as grading guidelines.

The other general comment made by most of the programs was the need to develop more options for types of senior projects that students could select to complete, ranging from design/project-based, internships, client-based group projects, research experiments, and others. It was noted that basic learning objectives must be included in all of these options to provide for some minimum standards.

Some programs indicated they wanted to move more towards group projects (HCS, AGB) and another program wanted to maintain the focus on individual student projects (ASM).

Conclusions

All programs indicated that the assessment of senior projects was a valuable exercise. They were able to identify many areas of weakness and identify solutions to improve senior projects. They all commented that the amount of variation between senior projects and faculty supervision was much greater that anticipated.

Many departments are examining ways to offer a larger variety of “options” for senior project. This can be beneficial for students by providing for more options to successfully complete senior project. This can also result in a larger variety of learning outcomes being accomplished by the different senior projects and create a challenge for the assessment of senior project in relation to the ULOs. The use of senior project as a reliable artifact of student learning must be examined carefully as we expand the options of ways to offer senior project.

Assessing Senior Project as an Artifact of Student Learning

Department _____Agribusiness Department _____

1. Comments on rubrics including recommendations for improvement.
There was overlap between the two rubrics and it would be better to combine the two rubrics for the purposes of a departmental assessment. One rubric is much more likely to be adopted than two rubrics.

2. Method of creating the population of projects collected and the sample read.
The senior projects being read were drawn from the Cal Poly University Library's Digital Commons website (digitalcommons.calpoly.edu) which covers the period between Spring 2009 and the time of the reading in May 2011.

All the AGB senior projects were downloaded from the Digital Commons and then reviewed to ensure that Wine & Viticulture majors were removed and to ensure that those senior projects whose documents were marked up were also removed. The senior projects had all identifying pages removed (student name, faculty adviser name) and were loaded onto computers. Final sample size assesses n=9.

The day of the reading, a group of faculty convened and all went through a norming session lead by the retired director of the university writing program that allowed the faculty to familiarize themselves with the critical thinking rubric and the writing rubric. After the norming session, groups of faculty read senior projects randomly drawn from the pool and, after reading and assessing the same senior project for both critical thinking and writing, the group convened to discuss the results. Towards the end of the session, all groups convened to discuss overall scores and impressions.

Limitations
The pool of senior projects cannot be considered random since there were far fewer senior projects put into the Digital Commons than were actually completed. Second, because of the limited time available and the limited experience of faculty in doing normed readings, it is highly unlikely that the scores were consistent across faculty or even within groups.

3. Results of rubric-based assessment as interpreted by the program.
It can be hypothesized that the papers that were available in the Digital Commons were more likely to be better than the ones that were not. If so, the general results regarding the assessment of critical thinking and writing were not good. Few papers were deemed of high quality in terms of the critical thinking and/or writing. There was a lack of consistency in writing styles, a lack of connection between structure of the paper and the topic covered, a general low quality in analytical approaches, a lack of depth and critical evaluation in literature reviews and a general lack of attention to detail in presentation. The sense of the faculty at the end of the session was that the problems in senior project were more systemic than maybe had been anticipated.

4. Recommendations for the improvement of senior project policies/procedures at all levels.

There was an agreement that the senior project needed to be overhauled. Initial suggestions to start addressing the problems found included the following:

- Development of a single rubric covering the critical thinking and writing;
- Provision of more examples of "good" senior projects to students;
- Moving senior project to the junior year; and,

- Emphasizing the "modeling" of good writing.

In summary, the existence of a problem with senior project was clearly understood by the department prior to the assessment exercise but the depth and breadth of the problems were not. Given the results of this exercise (and given previous concerns discussed by the faculty about senior project), the departmental curriculum committee was tasked to bring forward options for starting the "fix" of senior project.

Next Steps

As part of the broader work of implementing the new curriculum, the curriculum committee is developing some proposals about senior project options that the department hopes will not only improve the rate of success in senior project but will also improve the quality and consistency of the senior project artifact. These options include offering a range of senior project experiences (honors thesis, client-based group projects, use of internship) that students can choose from so that they will think about senior project in advance of taking the class and, thus, improve the chance of success. Underlying the design of these options, though, the curriculum committee has put forward some basic learning objectives that all options will be expected to meet. Specifically, each option must do the following:

- Incorporate a significant written component of sufficient quality to present to faculty and/or clients;
- Involve prior planning on the part of students, faculty and/or industry clients depending upon the option;
- Have similar prerequisites; and,
- Meet the Agribusiness Department Program Learning Objectives.

In addition, the current proposal is putting forward a faculty committee that will review both the proposals and assess (not grade) the final products to help ensure consistency and improvement in the departmental senior project requirement.

Assessing Senior Project as an Artifact of Student Learning

Department _____Agricultural Systems Management (ASM)_____

1. Comments on rubrics including recommendations for improvement.

None.

2. Method of creating the population of projects collected and the sample read.

Collected all available senior projects from 2010 for ASM students (n = 14). Hired an English professor to evaluate all 14 senior projects for writing and critical thinking assessment. Faculty not involved.

3. Results of rubric-based assessment as interpreted by the program.

Department had a lot of discussion about what the writing component really reflected. Since much of the senior project is an iterative process, there was concern about the writing component reflecting the faculty input and then the question became "What is the role of the faculty for senior project? Is it in providing input, feedback, guidance, teaching writing, etc.?"

In reading the senior projects in the department (BRAE and ASM) it was discovered that there is a lot of variability among the faculty in the expectations and the level of quality. Reviews of the BRAE senior projects revealed significant variation in scoring between faculty.

4. Recommendations for the improvement of senior project policies/procedures at all levels.

Because of the large amount of variation observed between faculty in the scoring of senior projects, the faculty decided to develop a scoring rubric to be used for grading guidelines (Spring 2011). This rubric gave standard point values to each element of the senior project. This will be implemented Fall 2011. The faculty have the perception that many students cannot handle the open, non-structured environment of the senior project where students are expected to structure the project on their own. The faculty had a lot of discussion about how to handle individual and team-based senior projects. Advisory council members felt the students already have enough team experiences in other courses so the senior project has more value as an individual experience and project. The faculty came to the conclusion to keep senior project primarily with an individual focus allowing for exceptions where appropriate. Also, it was recognized that the faculty needed to add more structure for the senior project to help provide guidance for the students. This resulted in a new structure in 461 and 462. All students will meet one hour per week in a classroom setting to provide deadlines and due dates for specific components of the senior project.

The value of senior project for an assessment artifact is that it does occur right before graduation, so it should be able to demonstrate mastery level of some learning outcomes but it cannot be used broadly as the only data point to assess critical thinking or writing.

Assessing Senior Project as an Artifact of Student Learning

Department _____Dairy Science Department _____

1. Comments on rubrics including recommendations for improvement.

None.

2. Method of creating the population of projects collected and the sample read.

All senior projects in DSCI for Fall 2010 were collected for this assessment. Original sample was 21 but one project was removed for plagiarism so the final sample size was 20. All faculty were involved in the assessment and went through a norming process. It was observed that there was a major faculty effect on the perception of quality so it was decided that a statistical approach would be used to correct for this observation. In incomplete black design was used as described below.

The objective of this work was to determine the level of achievement of Cal Poly Dairy Science seniors for criteria in two rubrics: Writing (WR) and Critical Thinking (CT). The data were scored evaluations from 8 faculty evaluators for 20 senior project manuscripts for five criteria in each of WR and CT. An incomplete block design was used such that, with the exceptions noted, each evaluator was randomly assigned to 6 manuscripts to evaluate WR and CT for each manuscript. The exception was one evaluator evaluated 7 manuscripts and one evaluator evaluated all manuscripts to enhance the connectedness between evaluators. Each of the five criteria in WR was evaluated on a 1 to 5 scoring scale indicating the level of mastery of the student. Each of the five criteria in CT was evaluated on a 1 to 4 scoring scale indicating the level of mastery of the student. In each scale the higher number indicated greater achievement. Prior to receiving their manuscripts to evaluate, the evaluators normed their scoring by evaluating and discussing three manuscripts that were independent from the set of manuscripts used in this analysis. A probit model with a normal distribution on the underlying scale was fit for the dependent variable of score with the independent fixed class effects of evaluator, rubric (WR or CT), criteria within rubric and student to determine if the scores were sufficiently consistent between evaluators. Least squares means for the main effect of question within rubric and the effects of each student for criteria within rubric on the scored scale were obtained by fitting a general linear model for the dependent variable of score on the independent fixed class effects of evaluator, rubric, criteria within rubric, student and the interaction of student with criteria within rubric. The main effect of evaluator was significant indicating differences between evaluators.

3. Results of rubric-based assessment as interpreted by the program.

1. Found a highly significant difference between faculty how faculty evaluated the same senior projects.
2. Senior projects demonstrated average critical thinking skills.
3. Senior projects demonstrated average writing skills.
4. Variation between senior projects was largely influenced by advising and how much supervision, input and guidance was provided by faculty. Also the philosophical approach of the faculty (purpose as described below) was important.
5. Difference in philosophy regarding purpose of the senior project to be used for an opportunity to teach the student (provide a lot of feedback, correction, editing of writing) or assessment of what the student is capable of performing.

4. Recommendations for the improvement of senior project policies/procedures at all levels.

Senior project class will be moved from the Fall quarter to Winter quarter. Communications will be sent out to students to let them know they must line up a project and start to plan so they will be ready to start senior project in Winter quarter. This will require students to have a plan organized and maybe even some data collected by the time they start the class in Winter. Faculty feel this may result in the students having some improvements in writing levels and critical thinking skills by waiting one quarter. Emails will be sent out to juniors and seniors guiding them to identify a faculty advisor and begin to develop a plan for senior project.

The three best senior projects will be submitted to the American Dairy Science Association poster competition for undergraduate students.

Senior project is probably not the best tool for assessment but it is one of the most useful capstone experiences, especially given the effort to collect data.

In our department, entrance and exit exams demonstrating the attainment of knowledge are valuable and survey of employers.

Assessing Senior Project as an Artifact of Student Learning

Department _____Horticultural & Crop Science Department _____

1. Comments on rubrics including recommendations for improvement.
Using the senior project to evaluate writing is problematic since so an advisor heavily edits many of them. So, we are really evaluating the faculty's writing ability as much or more than the students. It is troubling that it wasn't thought more at the university level before having to be implemented. The rubric was fine as long as it was the student's writing under scrutiny.

2. Method of creating the population of projects collected and the sample read.
We obtained copies of senior projects completed within the last two quarters (n=8). They represented in equal portions the various facets of our department's curriculum and areas of faculty interest/expertise. A faculty subcommittee of 4 evaluated the 8 senior projects. When there not a consensus on the score, the faculty had a combined discussion to come up with a final score.

3. Results of rubric-based assessment as interpreted by the program.
The results demonstrate we are in the "emergent" phase for senior projects and assessment of overall learning outcomes. These results are helping to focus the changes we will be implementing to improve our senior project course. The results show a subtle bimodal distribution in the cores based on topic, with crop science projects having more literature reviews and horticulture having a larger range of displays, designs and installation projects. For those students scoring lower in writing and critical thinking, we see that a written component has not been an expectation for those types of senior project topics. Therefore, we need to develop a "culture" of having a solid, well-written component expected for each senior project no matter the topic.

4. Recommendations for the improvement of senior project policies/procedures at all levels.

We need to rework our senior project courses so that students understand what is expected. Our department has quiet a bit of diversity in projects, ranging from rigorous scientific experiments to landscape installations or designs for which there typically has been no writing component. The challenge for us will be to implement a written component for every senior project and have faculty as well as student operating under the same expectations. We do not want to get rid of the diversity of project subject matter as that is a hallmark of our department. This exercise has shown that certain segments in our department have a scientific write up more engrained in their courses. As we change to a single major with many more courses being shared throughout our student's career we will monitor how effective these changes will be in facilitating a well thought out and well written senior project. One step will be to inform the students of the contents of the grading rubrics early in the process and use that as the means to illuminate expectations. Then faculty will be more apt to let the students write the report for themselves and receive the appropriate grade. It will be a more realistic assessment at that point.

Certain minimum standards need to be developed for senior project providing consistent expectations among faculty. The format or "deliverables" for senior project need to be defined. Considering a "Trade Journal" publication format as acceptable is being examined.

Use HCS 110 course as vehicle to communicate to students early in academic career what the expectations will be for senior project.

Problem currently is that the bulk of senior projects are on top of a full-time teaching load so how this is to be addressed is an issue.

Heading towards group projects.

MEMORANDUM

CAL POLY ORFALEA COLLEGE OF BUSINESS

To: Academic Programs - Delores Lencioni

From: Orfalea College of Business, Associate Dean Bradford Anderson

Date: June 10, 2011

RE: Senior Project Assessment, Phase III report for:
(A) B.S. Business Administration (B.S.B.A.);
(B) B.S. Industrial Technology (B.S.I.T.); and
(C) B.S. Economics (B.S. Econ)

In accordance with the published guidelines for senior project assessment, below are the responses from the Orfalea College of Business (OCOB) as to the Phase III report due today. OCOB provided its Phase I report in a timely manner (for each of the programs listed above) on March 17, 2011.

As OCOB programs are not under the current cycle of program review, no Phase II report was requested or required, and this submittal of the Phase III report completes the OCOB reporting obligation on this phase of Senior Project evaluation. The responses to Phase III are based upon input received from the representatives of the Undergraduate Curriculum Committee/Undergraduate Program Committee (UPC) from their consultation with their respective areas.

PHASE 3 REPORT:

"1. The nature of the senior project as a capstone defined in relationship to the ULOs."

> -ULOs are a strong influencing factor in reviewing curriculum, as well as an influence to learning goals and learning objectives used for AACSB accreditation. Therefore, ULOs indirectly align (via learning goals and learning objectives) to the senior project.

MEMORANDUM

CAL POLY ORFALEA COLLEGE OF BUSINESS

"2. The relationship of the project to an assessable artifact."

-It depends upon the nature of the project performed. See answer to #7, below.

"3. The cost of instruction."

- No commentary received.

"4. The integration of student learning in GE, the major, and the co-curriculum."

-This relies upon the learning goals and learning objectives established by UPC, and associated rubrics used for analysis. Those learning goals and learning objectives are attached to this memo. Faculty running senior project classes might select a sample deliverable of an "A" project as well as a sample of a "B", "C", etc., project to be submitted for review along with the rubric criteria for that class. All BSBA concentration projects assessed using the same rubric (e.g., the rubric for research reports) could be evaluated relative to the appropriate rubric.

"5. The tension between student advising and autonomy as well as other factors affecting completion."

-None noted.

"6. The use of external benchmarks."

-This is accomplished through our assurance of learning/assessment in connection with AACSB accreditation, where we establish learning goals and learning objectives and benchmark against peer and aspirant schools. This is not limited to senior projects, but is a broader assessment goal.

"7. Service learning and external engagement."

-We thought it best to attempt to categorize the senior project options in the Management Area along three dimensions: (1) *Delivery Method* with two levels (faculty-led or student-led), (2) *Student Composition* with two levels (independent

or team) and (3) *Type of Project/Deliverable* with seven levels (research paper, product development, business plan, certification, industry engagement, simulation, ICC (or other similar Venue – e.g. Concert)).

"8. Archiving and sharing projects."

-The OCOB private website has a means for archiving senior project deliverables.

-We are aware of the library resources for archiving written projects, but many of our senior projects are not centered upon a paper, but instead have other deliverables.

"9. Other compelling issues."

-It is essential to communicate to faculty the goals of the senior project.

ATTACHMENTS:
Learning Goals and Learning Objectives and points of assessment for three undergraduate programs.

BSBA Program Learning Goals and Objectives (updated 4/11)

Mission Statement: "We are an engaged learning community (LG1) that contributes to business (LG?/LG?) and society (LG?/LG?) through discovery and application (LG1)."

Learning Goals (LG): Students completing the undergraduate business program in the Orfalea College of Business will have a/be…		**Learning Objectives (LO):** Students graduating from our program will be able to…	
LG 1	General understanding of all major areas of business.	LO 1.1	Demonstrate breadth of knowledge and skills in general business fundamentals.
LG 2	Foundation in their specified discipline.	LO 2.1	Demonstrate depth of knowledge, skills, and perspectives within their selected, specific business discipline.
LG 3	Ethical and socially responsible decision makers.	LO 3.1	Recognize the social responsibilities of business organizations, including dimensions of ethics.
LG 4	Data-driven decision-makers.	LO 4.1	Be able to generate innovative solutions to business problems that are supported by appropriate data analysis and evaluation of alternatives.
LG 5	Understanding of how to work effectively in a diverse and global business environment.	LO 5.1	Function as members of society and as professionals with people who have ideas, beliefs, attitudes and behaviors that are different from their own.
LG 6	Effective communicators and team members.	LO 6.1	Demonstrate effective writing.
		LO 6.2	Demonstrate effective speaking skills.
		LO 6.3	Demonstrate effective peer leadership.
		LO 6.4	Demonstrate effective participation in teams.

Coverage of BSBA Program Learning Objectives in the BSBA Curriculum

			Learning Objective								
BSBA Core Course Numbers & Names			**1.1**	**2.1**	**3.1**	**4.1**	**5.1**	**6.1**	**6.2**	**6.3**	**6.4**
BUS	207	Legal Responsibilities in Business	P								
BUS	214	Financial Accounting	P	P							
BUS	215	Managerial Accounting	P	P		S					S
BUS	342	Fundamentals of Corporate Finance	P		S	P					
BUS	346	Principles of Marketing	P		S	P		P	S		P
BUS	387	Organizational Behavior	P		S	P	P!	S	S	P!	P!
BUS	391	Information Systems		P		P					
BUS	401	General Management and Strategy	P	P		P!		P	P		S
BUS	404	Government and Social Influences	P		P!						
ECON	221	Micro ECON	P		S		S				
ECON	222	Macro ECON	P		S		S				
Students choose from below one international BUS or ECON course AND one production IT course.											
BUS	302	Int'l & Cross-Cultural Mgmt.	P	P	P	P	P				
BUS	303	Introduction to International Business	P	P	S	P	P				
BUS	410	The Legal Env. of Int'l Business	P								
BUS	433	International Finance		P							
BUS	446	International Marketing	P								
ECON	330	International Trade	P			S	S				
IT	326	Product Evaluation				S		S	P	S	
IT	330	Issues of Packaging						S	S		S
IT	341	Plastic Processes and Applications				P			P		P
IT	371	Decision Making in Supply Chain, Services, and Project Management			P	P	P	P	S	P	P

P	Primary Coverage	**S**	Secondary Coverage
!	Where Summative Assessment will Occur		

Course coverage of the economics learning objectives is presented in the following table

Economics Undergraduate Program Learning Objectives	
Learning Objective 1a	Students are able to recall and interpret intermediate microeconomic theory.
Learning Objective 1b	Students are able to recall and interpret intermediate macroeconomic theory.
Learning Objective 1c	Students are able to apply microeconomic theory or macroeconomic theory to explain and compare solutions to important business, economic or social problems.
Learning Objective 2a	Students are able to apply algebraic, graphical or statistical methods to explain and compare solutions to important business, economic or social problems.
Learning Objective 2b	Students are able to employ economic research methodology to explain and compare solutions to important business, economic or social problems.
Learning Objective 2c	Students are able to employ technical writing skills to explain and compare solutions to important business, economic or social problems.
Learning Objective 3a	Whenever relevant and appropriate, students identify and examine diverse perspectives when explaining and comparing solutions to important business, economic or social problems.
Learning Objective 3b	Whenever relevant and appropriate, students identify and examine the ethical implications of proposed solutions to important business, economic or social problems.

Assessment and Coverage of Learning Objectives								
Economics Courses	**Learning Objective**							
	1a	**1b**	**1c**	**2a**	**2b**	**2c**	**3a**	**3b**
Econ 221: Microeconomics	S		S	S	S		S	S
Econ 221: Macroeconomics		S	S	S	S		S	S
Econ 311: Intermediate Microeconomics	P		P	P	S	S	S	S
Econ 313: Intermediate Macroeconomics		P	P	P	S	S	S	S
Econ electives (300-400 level)	S	S	P	P	P	P	P	P
Econ 464: Applied Senior Project	S	S	P!	P!	P!	P!	P!	P!
ETS Exam	!	!						

Symbol Key		
P = Primary Coverage	S = Secondary coverage	! = Summative Assessment

Industrial Technology Program Learning Objectives

Students graduating from our program will be able to…	
Learning Objective 1	Demonstrate general knowledge within their area of interest in Industrial Technology.
Learning Objective 2	Explain and act on ethical issues regarding the applications of technology
Learning Objective 3	Explain and act on issues of sustainability regarding the applications of technology
Learning Objective 4	Act upon decision tools and methods and explain the action taken.
Learning Objective 5	Explain the important elements of team success.
Learning Objective 6	Demonstrate effective verbal communications skills
Learning Objective 7	Demonstrate effective technical written communications skills

Coverage of Learning Objectives in Industrial Technology

			Learning Objective						
BS Core Course Numbers & Names			**1**	**2**	**3**	**4**	**5**	**6**	**7**
IT	137	Electrical/Electronic Systems	P	S			S		
IT	150	Industrial Power Systems	P	S	S	S	S		
IT	233	CAD	P			S			
IT	260	Manufacturing Processes	P			P	S	S	S
IT	326	Product Evaluation	P		S	S	S	P	P
IT	329	Industrial Materials	P		S	P	S	S	S
IT	330	Fundamentals of Packaging	P		P		S	S	S
IT	341	Plastics Process & App (GE - F)	P	S	P	P	P	P	P
IT	403	Quality Systems Management	P		S	P	P!	S!	
IT	407	Applied Industrial Product Design	P		S		P	P	P
IT	408	Paper and Paperboard Packaging	P		S		S		S
IT	410	Operations Planning and Control	P	S		P!			
IT	411	Industrial Safety & Quality Program	S	S	P	S	S	S	S
IT	428	Commercialization of New Tech	P	S				S	P
IT	475	Packaging Performance Testing	P!		S!	P	S		S

Choose Two*			**1**	**2**	**3**	**4**	**5**	**6**	**7**
IT	402	New Industrial Enterprises	P	S	S	S	S	S	S
IT	406	Industrial Sales	S	P	P	P	S	P	P
IT	435	Packaging Development	P		P	P	P	P	P

Senior Project - Choose One			**1**	**2**	**3**	**4**	**5**	**6**	**7**
IT	461,2	Senior Project	P!			P!			P!
IT	464	Senior Project Seminar	P!			P!			P!

Coverage Key

P	Primary Coverage	**S**	Secondary Coverage
!	Where Summative Program Assessment takes place		

Industrial Technology Program Learning Objectives

Students graduating from our program will be able to…	
Learning Objective 1	Demonstrate general knowledge within their area of interest in Industrial Technology.
Learning Objective 2	Explain and act on ethical issues regarding the applications of technology
Learning Objective 3	Explain and act on issues of sustainability regarding the applications of technology
Learning Objective 4	Act upon decision tools and methods and explain the action taken.
Learning Objective 5	Explain the important elements of team success.
Learning Objective 6	Demonstrate effective verbal communications skills
Learning Objective 7	Demonstrate effective technical written communications skills
Learning Objective 8	Explain and act on interactions between humans and technological systems

Coverage of Learning Objectives in Industrial Technology, continued…

Electives Choose Two			1	2	3	4	5	6	7
BUS	342	Fundamentals of Corporate Finance							
IT	371	POM	P			P	S	S	
IT	408	Corrugated Protective Packaging	P		S		S		S
IT	409	Machinery for Packaging	P		S	P	P	S	P
IT	435	Packaging Development	P		P	P	P	S	P
IT	445	Computer Numerical Control	P				S		S
IT	451	Facility Equipment and Systems	P		S		S	P	P
IT	454	Facilities Development							

Support Courses Within College			1	2	3	4	5	6	7
BUS	212	Financial Accounting for NonBUS majors							
BUS	346	Principles of Marketing							
BUS	391	Information Systems							
ECON	201	Survey of ECON							

Coverage Key

P	Primary Coverage	**S**	Secondary Coverage
!	Where Summative Program Assessment takes place		

Report on Senior Project Assessment for CENG
'SP2/Part III' - Findings and Best Practices
Fred DePiero -- Draft Version 2

This report summarizes the best practices CENG uses to assess senior projects and other student abilities. We will broadly document our efforts because senior projects alone do not allow us to accurately evaluate all of our program outcomes.

ABET accreditation requirements significantly influence our assessment efforts. For example, ABET defines student learning outcomes at the program level, and these are identical for all engineering programs. Although Cal Poly's University Learning Outcomes (ULOs) outcomes are roughly similar to those of ABET and consequently offer reasonable similarities in student expectations, we emphasize ABET A-K outcomes to simplify the accreditation process. Because ABET encourages data-driven decision making, this report includes brief descriptions of the ABET requirements to provide context. This report also includes some examples of program improvements based on assessment results.

PLEASE TREAT THIS REPORT AS CAMPUS CONFIDENTIAL. Restricted dissemination is appropriate for assessment activities as it encourages introspection and faculty members' honest evaluation of a program. This report may be distributed to advisory boards provided that the board maintains confidentiality..

This report assumes some familiarity with assessment methods and terminology, so it does not include definitions for direct / indirect or summative / formative methods, for example. Also note the interchangeable use of the terms 'outcome' and 'objective' in this report. 'Outcomes' describe student abilities developed during a degree program.

A few general comments appear next which may help set the tone of our assessment and evaluation efforts. Examples follow in the appendices. The general comments address the following points:

- Why faculty should define program outcomes
- Why we should perform outcomes assessments
- What we should assessed
- Use a variety of assessment measures
- Combining diverse measures
- Why program improvement efforts should incorporate assessment results
- Benefits of an ongoing process

Why Faculty Should Define Program Outcomes

Defining outcomes benefits students by outlining a comprehensive set of goals for their education. Outcomes provide perspective when evaluating the sufficiency of a curriculum to meet the needs of an evolving student body. Thus introspectively reviewing a degree program to define outcomes helps ensure appropriate breadth and depth of curriculum as fields expand and develop.

Unfortunately, the university frequently fails to communicate program outcomes to students. Consequently, students do not have a context for the learning priorities of a course, a series of courses, or across a curriculum. Students often feel they are 'drinking from a fire hose.' They grasp at the abilities and skills that appear most critical to passing exams and then flush all seemingly disposable information as they leave a final. By conveying course and program level outcomes, we show students the essential, career-long abilities and concepts. This allows us to design curriculum that can provide repeated exposure to the most critical concepts as students learn, develop, and master abilities.

It is essential to define and publish outcomes. They equip students with the framework and context for information and skills development that will span a degree program.

ABET's (A-K) program-level outcomes appear in Appendix I, which also includes a standardized syllabus that describes the relationship between the course and the program-level outcomes.

Why We Should Perform Outcomes Assessment

First, the Chancellor's office requires these assessments for program review, as do accrediting agencies. But we should consider the question aside from obligation, particularly for programs that are not accredited by external agencies.

So what is the value? And why do accrediting agencies require outcomes assessment?

Course-based assessments do not sufficiently identify gaps in learning *across* a program. To faculty members teaching their individual courses, a student's grasp of the course material alone may seem sufficient to prepare a student for future courses and careers. However, this evaluation is inaccurate because course-level evaluations are narrow when compared to the comprehensive expanse of learning required for a degree. Summative measures of student abilities often reveal that students struggle to retain and synthesize ideas that are dispersed across a curriculum.

Summative assessments show the need for program improvements more accurately than course-based approaches. Outcomes assessment allows us to check student abilities at graduation and provide a neutral perspective when considering program improvements.

What Should We Assess

While it is relatively easy to assess narrower course-level outcomes, assessments at the program, college, or university levels are typically more difficult. Because we express them in broader terms, program or university-level outcomes are subject to varied interpretation, particularly when considered from the standpoint of different disciplines.

So why have broadly defined outcomes at the program, college, or university levels? Why not just use easily assessed course outcomes?

Not every student excels in every area of a course or program, and the broader outcomes describe a more comprehensive persona. Broader outcomes provide a richer and more diverse picture of what makes a 'successful' graduate. They also give a common framework that allows us to pool assessment results across campus. This is beneficial during institutional assessment processes such as WASC, which are concerned with the success of students across the university. Pooling results at the college or university levels helps programs to evaluate their relative strengths in a local campus setting.

We should avoid broadly assessing program-level or university-level outcomes. Rather, consider identifying specific, measurable abilities that are related to a given outcome. Assessing specific and measurable skills helps illuminate the need for program improvements and puts assessment efforts into a more meaningful disciplinary context.

See Appendix II for some examples of specific measurable abilities defined for some CENG programs.

Use a Variety of Assessment Measures

In *Our Underachieving Colleges,* Derek Bok makes the brilliant point that even an imperfect assessment process can yield useful results. This observation leaps past fruitless hours of debate by faculty on the merits of various approaches. Just try something. It is very likely that faculty members will Learn by Doing!

Following Bok's logic, an endless debate over small details has limited value because no single assessment method is perfect. This necessitates a variety of diverse assessment techniques. A myriad of techniques is more reliable because it mitigates the shortcomings or limitations of any one methodology.

Using a variety of measures benefits the evaluation process because it provides better data. Consider a situation where several different assessment methods indicate similar issues (e.g. students having difficulty with X). The conclusion that the program needs improvements is stronger when many different indicators point to a similar conclusion. Using a single measure can lead to either invalid or indefensible conclusions.

Specific assessment questions and types of assessment typically vary among programs. Where one program uses standardized exams and surveys as primary measures, another might prefer focus groups and advisory boards. When and with whom an assessment process runs also varies among programs (e.g. surveys to juniors, focus groups for seniors in a capstone course, etc.). Identical assessment techniques across multiple programs are red flags that methods may be inaccurate. Because specific, measurable skills differ between programs, details of issues queried differ as well.

In order to be accurate, robust, and sustainable, assessment methodologies will vary among programs. Sharing best practices is important in order to expeditiously develop effective assessment methods. Given a good example, faculty members can readily adapt assessment techniques to their program.

Note: The 'Collegiate Learning Assessment' is an example of an attempt to use an identical metric ('yardstick') across <u>all programs</u> at <u>multiple institutions</u>. Beware!

Appendix III lists various assessment instruments employed in CENG.

Combining Diverse Measures

A variety of instruments improves the reliability of assessment processes; assessment using specific, measurable skills improves accuracy and disciplinary relevance. Because we use these diverse measures, we need a process to pool results for decision-making purposes.

How do we combine diverse measures? Even combining data for a single outcome within a single program can be difficult. This can be even more problematic when combining data across a college or campus-wide.

One simple method to combine diverse measures is to have faculty members identify a target performance level for each measure. Comparing performance against the target level indicates whether students' abilities are below, above, or roughly equivalent to the target. Then one can agglomerate data by simply tallying the number of measures at or above target. A result in this style might appear as '4/5 measures indicate satisfactory performance in area X.'

This method of combining diverse measures is flexible and does not restrict the specific abilities or issues assessed. Nor does it restrict the type or timing of instruments. The approach allows us to pool results at any level, with either summative or formative evaluations.

See Appendix IV for some examples of performance targets identified by program faculty. The appendix also includes some details and results of the evaluation process.

Why Program Improvement Efforts Should Incorporate Assessment Results

Using quantitative assessment methods to inform improvement efforts helps faculty members to understand the need for meaningful program change. Curricular changes driven by the loudest person in the room are antithetical to this methodology. Using quantitative and systematic approaches incorporates input from faculty members more fairly.

To provide a more thorough process, we can use quantitative methods to establish a baseline performance level before introducing an improvement. This baseline provides a means to gauge performance after implementing a program change, thus indicating success or the need for further investigation.

We can use quantitative approaches to help prioritize or identify program areas that need improvement. One common technique displays assessment data on a scatter plot with axes of 'performance' versus 'importance.' Faculty members – and other program constituents – can vote on the importance. Thus, all faculty members have the opportunity to contribute fairly in the assessment and evaluation process. The scatter plot is a decision-making tool where more important student abilities that have a lower performance are easy to spot. Weighing importance provides an introspective view on program outcomes and is thus an auxiliary benefit.

The emphasis on quantitative methods should not discount the role of faculty judgment in the program improvement process. Quantitative approaches simply provide tools that compliment and guide the process. Faculty observation of student performance is as valid a criterion to commence an improvement effort as are statistical comparisons. Faculty observations, suggestions from industrial advisors, and inspiration from scholarly sources are all valuable means to inspire program improvements.

When a university or program first notes shortcomings in student learning (perhaps by faculty observation), issues may lack the clarity needed to identify appropriate program improvements. Quantitative approaches can assist in these situations. For example, we can use assessment tools to check formative abilities by class level, to examine the value added by a given course, or to verify areas of strengths and weaknesses more specifically. In this way, quantitative methods help identify the root cause of a shortcoming and better refine a program change.

Appendix V includes documentation of program improvements. Improvement justifications cite multiple sources of information.

Benefits of an Ongoing Process

Ongoing assessment efforts are necessary due to external factors such as an evolving demographic for the student body, and due to the continual expansion of disciplines. Some accrediting bodies such as ABET also explicitly require continuous assessments. Setting these external influences aside, ongoing efforts are practical because they remedy certain logistical issues, making some processes easier to run. They also improve the quality of assessment results.

When running a survey process, it can be troublesome to acquire a snapshot of an entire demographic, for example graduating seniors. Problems arise because students may be off campus in a given quarter or because their class standings change throughout the year. Logistical problems of this sort reduce acquired data. A continuous assessment process can catch all students more easily as they gradually progress past a triggering criterion.

Continuous processes also yield more useful data. For example, small programs may not have enough students to assess in order to provide meaningful results. With a continuous process, a smaller program can accumulate data over time for a student group of interest (e.g. seniors or students in a particular course).

Ongoing assessment data that spans program outcomes also provides very useful baseline information. If the need for a program improvement arises, we can re-examine past assessment measures or past student artifacts in a new light. This helps define shortcomings and can reinforce the need for an improvement. It also validates the effect of an improvement after it has taken effect. An ongoing process also provides repeated trials to verify observations.

Lastly, a continuous process more readily evolves and improves. Refinements to an assessment process include the logistics of when and where measures occur. They give us the opportunity to raise the bar on student expectations. These kinds of refining processes are signs of a healthy learning community. With an ongoing process, we don't have to get it right the first time.

Bonus Topic: Assessing Career Accomplishments of Graduates

Identifying career accomplishments and assessing alumni is somewhat peculiar to the ABET accreditation requirements; we will discuss this to some extent as a bonus topic. Faculty members' efforts to identify broad career accomplishments for their graduates provide a good opportunity for introspection. The process can also shed light on curricular dead wood or on absent topics.

ABET refers to the career accomplishments of graduates as 'Program Educational Objectives.' Examples appear in Appendix VI. The appendix expresses career accomplishments – depicted personas of successful graduates – in broad terms (by necessity.) Assessing these accomplishments is challenging and in some ways parallels the challenges of assessing ULOs due to the nonspecific definitions.

To assess career accomplishments, programs identified simple, specific examples and then asked alumni Yes/No questions regarding their experiences. This created an accurate survey instrument with specific questions. Respondents could quickly complete the survey because of the Yes/No questions.

The translation of broader accomplishments into more specific measurable terms has proven an effective means of surveying alumni. Hopefully, this description is informative to the campus community.

Appendix Ia. Excerpt of ABET Requirements

Paraphrasing, the style of assessment ABET encourages, includes:

- Data-driven decision making
- Continuous improvement involving assessment and evaluation
- Sustainable practices

Data-driven decision-making avoids the typical process of program change, which the loudest faculty member usually dominates. Instead, decisions should be based on a variety of information sources. These may include both direct and indirect measures.

Common terms, as defined by ABET:

> **Assessment** – Assessment is one or more processes that identify, collect, and prepare data to evaluate the achievement of outcomes.
>
> **Evaluation** – Evaluation is one or more processes for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which program outcomes are being achieved and results in decisions and actions to improve the program.
>
> **A-K Program Outcomes** – Describe abilities of students. Has a similar level of specificity of student abilities as Cal Poly ULOs.

ABET strongly encourages programs to identify and establish measurable attributes for each Outcome. ABET commonly defines measurable attributes with either rubrics or several specific skills. Rubrics improve uniformity in the assessment process and provide perspective on student work that is geared toward program outcomes and distinct class assignments. Specific observable activities develop the skills associated with an Outcome. Thus, we can measure skills directly by selecting or defining student work that exemplifies a given skill.

Appendix Ib. More Excerpts from ABET Requirements

The following are excerpts taken directly from the ABET Criteria for engineering programs. (See abet.org for more info)

Criterion 3: Program Outcomes

Engineering programs must demonstrate that their students attain the following outcomes:

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

Program outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program. Program outcomes must foster attainment of program educational objectives.

There must be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program outcomes are attained.

Criterion 4: Continuous Improvement

Each program must show evidence of actions to improve the program. These actions should be based on available information, such as results from Criteria 2 and 3 processes.

Appendix Ic. Example of a Standardized ABET Course Syllabus

EE 302: Classical Control Systems (3 credits)

Prepared by:	Xiao-Hua (Helen) Yu (October 16, 2007)

Course Description: (2007-2009 Catalog)
Introduction to feedback control systems. System modeling. Transfer functions. Graphical system representation. System time response, stability. Root locus. Frequency response. Compensation. 3 lectures.

Required/Elective:

	CPE	CS	EE	SE
Required			**x**	
Elective	**x**	**x**		

Prerequisite Courses:
Prerequisite: EE 228, EE 255&295. Concurrent: EE 342. Suggested: EE 368.

Prerequisites by Topic:
1. College-level calculus and differential equations.
2. Laplace transforms.
3. Convolution and its application to Linear time invariant systems.
4. Frequency response.

Textbook: (and/or other required material)
Modern Control Systems, 11th ed., Dorf and Bishop. Pearson Prentice Hall, 2006, or
Modern Control Engineering, 4th ed., K. Ogata. Prentice Hall, 2002, or
Control Systems, 3rd ed., Naresh K. Sinha. New Age International Publishers, 1998

References:
None

Course Coordinator:
Xiao-Hua (Helen) Yu

URL (if any)

Course Goals/Learning Outcomes/Expected Performance Criteria

(See the corresponding course binder and the outcome binders for performance criteria)

This course will provide the student a substantive background in the field of classical control systems, including both time and frequency domain techniques. After completing the course, the student will be able to:

1. Model a given system (including mechanical, electrical, and electromechanical systems).
2. Derive and apply the following types of linear system analysis: transfer function, impulse response, convolution, multiplication of transforms in frequency domain, block diagram representation and reduction.
3. Obtain system time domain response, including transient response and the stability of a system.

4. Plot and apply Root locus for linear system analysis, including dominant pole approximation and the estimation of second order characteristics from dominant poles.
5. Obtain system frequency response. Construct Bode plots. Determine gain and phase stability margins from Bode plots.
6. Design a compensator, including lead and lag compensators.

Course Assessment Methods
Graded homework, quizzes or midterm exams, and final exam

Relationship of Course to EAC Program Outcomes
(H=high, M=medium, L=low, N=none; n/a=not applicable)

	3a	*3b*	*3c*	*3d*	*3e*	*3f*	*3g*	*3h*	*3i*	*3j*	*3k*	*8l*	*8m*	*8n*
CPE	**H**	**M**	**M**	**M**	**H**	**L**	**L**	**L**	**L**	**L**	**H**	**N**	**H**	**H**
EE	**H**	**M**	**M**	**M**	**H**	**L**	**L**	**L**	**L**	**L**	**H**	**N**	**H**	**H**
SE	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**			

Major Topics Covered: (number of hours each)

1. Course introduction and overview. (1)
2. System Modeling: modeling of electrical, mechanical, and electromechanical systems; nonlinear system behavior and linear models. (3)
3. Linear Differential Equations Review: Characteristic equation and eigenvalues. Homogeneous and particular solution. The zero input and zero state response. (2)
4. Laplace Transform Review: Definition and review of axioms. Solving differential equation by Laplace transform (including nonzero initial conditions, inverse transforms and partial fraction expansion). (2)
5. Transfer Function: The impulse response, convolution and multiplication of transforms, block diagram and block diagram reduction, signal flow graphs. (3)
6. System Response and Stability: Transient response, steady state error, types of stability and their relationships to eigenvalues, Routh-Hurwitz stability and stable range of parameters from Routh-Hurwitz test. (3)
7. Root Locus: Graphical techniques to generate root locus plot. Dominant pole approximation, and the estimation of second order characteristics from dominant poles. (6)
8. Frequency Response: Bode plot (simple poles and zeros, complex conjugate poles), frequency response metrics, open and closed loop system plots, gain and phase stability margins. (3)
9. Compensation: Lead and lag compensator design using s-plane and frequency response methods. (5)
10. Midterms (2)

Laboratory Projects and Schedule (specify number of weeks on each)
See corresponding lab course, EE 342.

Contribution of Course to meeting EAC Category 5 Requirements

College-level mathematics and basic sciences:	0 credits
Engineering Topics (Science and/or Design):	3 credits
General education component:	0 credits

Appendix IIa. Measurable Abilities for each Program Outcome in EE

The following lists describe measurable abilities associated with each program outcome. This list comes directly from a self-study; hence items are identified in disciplinary jargon. Nevertheless, note the use of action verbs from Bloom's taxonomy ('identify', 'design', 'analyze').

Note, the EE program chose to define two additional outcomes, beyond ABET's minimum of A-K. Also, while A-K is common to all engineering programs (analogous to ULOs) notice the disciplinary character brought out via these specific, measurable abilities.

Outcome a) An ability to apply knowledge of mathematics, science, and engineering

Abilities defined:

1. Able to evaluate basic geometrical quantities and mathematical expressions.
2. Knowledge of basic sciences and associated analysis techniques.
3. Proficient with basic analyses associated with other engineering disciplines.

Outcome b) An ability to design and conduct experiments, as well as to analyze and interpret data

Abilities defined:

1. Proficient with the basic operation of instruments.
2. Proficient with basic calculations needed to support experimental procedures.
3. Able to identify parameters for a model, given experimental data.
4. Able to design experimental procedures for test and verification purposes
5. Identify an appropriate model or parameters, given experimental data.

Outcome c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

Abilities defined:

1. Proficient with Type 1 design issues in Digital Design
2. Proficient with Type 1 design issues in Electronics
3. Proficient with Type 1 design issues in E&M
4. Proficient with Type 1 design issues in Signals & Systems
5. Proficient with Type 1 design issues in Power

Note: 'Type 1' refers to a 'structured' design procedure. This is in contrast to an open-ended type of design problem. Some examples of Type 1 design are designing a lead compensator via a Bode plot, designing a stub tuner via a Smith chart, and designing combinational logic via a K-Map.

Outcome d) An ability to function on multidisciplinary teams

Abilities defined:

1. Recognize value of a MD team: broad skill set
2. Communicate effectively with colleagues in other disciplines and listen well
3. Employ flexible styles and behaviors and recognize the style of another
4. Identify when problems occur due to poor team member interaction
5. Identify ways to improve team dynamics

Outcome e) An ability to identify, formulate, and solve engineering problems

Abilities defined:

1. Able to identify functionality of a basic system or component described mathematically in hardware or software
2. Able to reason and think critically and evaluate problem solutions
3. Find appropriate models for common circuits and systems
4. Able to estimate quantities and their uncertainty

Outcome f) An understanding of professional and ethical responsibility

Abilities defined:

1. Identify situations with ethical concerns over intellectual property (IP), non-disclosure agreements (NDA), conflict of interest, non-compete clauses, use of counterfeit software
2. Knowledge of IEEE code of ethics
3. Identify situations with inappropriate professional behavior, for example sexual harassment

Outcome g) An ability to communicate effectively

Abilities defined:

1. Proficiency establishing and justifying a position with a written commentary
2. Proficiency writing technical reports
3. Proficiency with oral presentations of technical material
4. Read and extract information from a data sheet, schematic or other technical documents

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

Abilities defined:

1. Identify societal impact associated with a project or product
2. Awareness of response of science and technology to needs driven by society, health & safety, or the environment
3. Awareness of the potential for a negative impact of science and technology on society, perhaps resulting from an unintended consequence

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

Abilities defined:

1. Able to learn new techniques, tools, or devices outside the classroom environment
2. Find appropriate technical resources
3. Able to identify need for and to plan for additional training or learning

Outcome j) A knowledge of contemporary issues

Abilities defined:

1. Demonstrate awareness of current or recent events in nation or world that could influence a student's career path or the field of electrical engineering
2. Identify sustainability issues associated with a project or product
3. Identify a potentially disruptive technology.
4. Demonstrate awareness of the way technology impacts and is impacted by public policy [local, state or federal level].

Outcome k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Abilities defined:

1. Proficient with computer-based simulation and analysis tools
2. Proficient with basic analyses and fundamental concepts in circuits, electronics, signals & systems, E&M, and power
3. Design and implement software-based subsystems in a high level language
4. Able to synthesize concepts between different areas of EE

Outcome l) **Knowledge of probability and statistics, including applications appropriate to the program name and objectives**

Abilities defined:

1. Able to compute basic statistics such as mean variance and standard deviation given numeric data
2. Knowledge of fundamental concepts associated with random variable theory
3. Able to compute probabilities of simple events [e.g. dice rolls]

Outcome m) **Knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives**

Abilities defined:

1. Proficient with math & science to support analysis & design of digital circuits
2. Proficient with math & science to support analysis & design of analog circuits and devices
3. Proficient with math & science to support analysis & design in electromagnetics
4. Proficient with math & science to support analysis & design in signals & systems area.

Outcome n) **Knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics**

Skills defined:

1. Proficient with calculations involving complex variables
2. Proficient with basic calculations involving matrices and vectors.
3. Knowledge of methods to solve linear differential equations with constant coefficients
4. Proficient evaluating expressions involving discrete-time signals

Appendix IIb. Measurable Abilities for each Program Outcome in MATE

In this example, MATE faculty chose to use a rubric to define PLOs more precisely.

	Outcome			application	evidence provided
A	An ability to apply knowledge of mathematics, science, and engineering			All courses	Junior series basic exams (Fall 2007), Spring Junior course Oxidation Analysis
	Integration of Support Courses				
	developing	meets expectations	exceeds expectations		
	qualitatively describes the underlying math, physics and chemistry to support decisions or conclusions without ability to quantitatively apply knowledge	+quantitatively describes the underlying math, physics, and chemistry and relevant constitutional equations to support decisions or conclusions	+creates new models (math or otherwise) to support decisions or conclusions		
B	An ability to design and conduct experiments, as well as to analyze and interpret data			310/315, 350/355, senior project	Prosthetic device design improvement; Spring Junior course Oxidation Analysis
	developing	meets expectations	exceeds expectations		
	articulates a hypothesis and metrics that can be used to test the hypothesis; creates operating procedure, experimental conditions, proper run order and data collection methods without abilities to correctly analyze results	+utilizes appropriate statistical tests to analyze results; discusses limits of the analysis and verifies underlying assumptions on which the analysis is based	+creates new prediction models based on prior experimental results		

*all. In practice, we consider this to be 98% of the students achieving a median score of 2 (meets expectations) or 3 (exceeds expectations), within a 95% confidence interval.

G	an ability to communicate effectively			all courses	senior project faculty ratings
	Explains the mechanisms of operation of their designs				
	developing	meets expectations	exceeds expectations		
	Qualitatively describes how the design functions, but unable to relate the subcomponent functions to the functionality of the larger system.	+ Qualitatively describes how each subcomponent of the design functions	+ Presents the functional requirements to the client and documents feedback		
	Effectively communicates technical information in written form				
	developing	meets expectations	exceeds expectations		
	Uses a professional tone and style, but is unable to organize written material in a logical progression for a specified audience	+ Report is clearly organized and follows a logical progression	+ All parts of report are designed to minimize effort of reader to obtain information		
	Effectively communicates technical information in oral form				
	developing	meets expectations	exceeds expectations		
	Presentation has a professional and clear appearance, but it lacks clarity and is disorganized.	+ Presentation is clearly organized and follows a logical progression	+ All parts of presentation are designed to minimize effort of reader to obtain information		
H	the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context			110, 120, 130, 232, 222	Senior project EAB ratings/presentations
	developing	meets expectations	exceeds expectations		
	Identifies an issue of global importance and articulates how engineering solutions are related to that issue.	+ Describe the relationship between the engineering solution and potential global economic, environmental and societal ramifications	+ For any engineering solution, create a causal loop diagram that maps potential impacts across global economic, environmental and societal domains		
I	a recognition of the need for, and an ability to engage in life-long learning			all courses	MSLQ, SDLRS ratings
	Challenges oneself to learn what one needs				
	developing	meets expectations	exceeds expectations		
	+ Identifies the gaps in their own knowledge, but is unable to fill these gaps.	+ Researches needed information to fill this gap	+ Fills knowledge gap through research and by explaining the information in their own terms		
J	a knowledge of contemporary issues			110, 120, 130, 232, 222	
	<Please see item H>				
K	an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice			222, 225, 235, all junior-level courses	222 projects (CES); Fiber optic (Solidworks); Prosthetic (Minitab); 235
	Engineering Design				
	developing	meets expectations	exceeds expectations		
	Provide a Solidworks drawing of their design	+ Provide a Solidworks drawing of your design that includes an isometric or trimetric view that is correctly dimensioned	+ Provide a Solidworks drawing of your design that includes a dimensioned view of the assembly and its respective components		

Appendix IIIa. Summary Lists of Assessment Instruments

The following lists identify assessment instruments used by programs in CENG. Note the variety, beyond just senior project, for example. Also note the emphasis on upper division. Both direct and indirect measures are included.

Many of these assessment processes are implemented at the program level, direct measures in particular. Some processes are run at the college level (senior surveys and alumni surveys) and some at the university level (employer surveys and WPE). The FE Exam is defined and administered by a CA State agency. Lastly, note the involvement of Industrial Advisory Boards in some cases as well.

This info was pulled from self-study reports written in 2008.

Aerospace Engineering

- Senior Design
- Senior Project
- Industrial Advisory Board Evaluation of Senior Project
- Graduating Senior Survey
- Writing Proficiency Exam (WPE)
- Senior Portfolio
- Graduate School Statistics

Civil Engineering

- Graduating Senior Survey
- Senior Design Project Evaluations
- Senior Design Assignments and Exams
- Writing Proficiency Exam (WPE)
- Course Assignments and Exams
- Extracurricular Projects
- FE (Fundamentals in Engineering) Examination
- Employer Survey

CPE

- CPE 315 Midterm questions
- Senior Assessment Exam (Multiple Choice)
- CPE 450 System test assignment
- CPE 450 Final report
- CPE 350 Level N design assignment
- CPE 350 Teaming exercise
- CPE 350 Team process assignment

- CPE 450 Peer evaluation
- Senior Assessment Exam (Short Essay)
- CPE 329 Final Exam Problem (Essay)
- CPE 450 Technical white paper & presentation
- CPE 350 Reflection
- Graduating Senior Survey
- Alumni Survey
- Employer Survey
- Writing Proficiency Exam (WPE)

CSC

- Senior survey
- Employer Survey
- Alumni survey
- IAC discussions
- Faculty curriculum review
- Focus Group with Students
- Senior project archival
- Direct measures
- Writing Proficiency Exam (WPE)

EE

- Junior-Level Exam
- Senior-Level Exam
- Senior Project Analysis
- Writing Proficiency Exam (WPE)
- Multidisciplinary Project Questions in EE 255
- FE (Fundamentals in Engineering) Examination
- Graduating Senior Survey
- Alumni Survey
- Faculty Survey
- Industry Advisory Board Survey
- Employer Survey

ENVE

- FE (Fundamentals in Engineering) Examination
- Industrial Advisory Board Input
- Graduating Senior Survey
- Employer Survey
- Writing Proficiency Exam (WPE)
- Focus Group with Students

IE & MfgE

- Graduate job placement (salary and title) surveys
- Alumni surveys
- Advisory board (IAB) surveys
- Employer surveys and job posting data
- Senior-level exam
- Graduating senior surveys
- Senior Exit interviews
- FE (Fundamentals in Engineering) Examination
- Writing Proficiency Exam (WPE)
- Focus Group with Students

MATE

- Graduating senior surveys
- Evaluation of questions in homework or exams from select courses
- Evaluation of projects from select courses
- Evaluation of Senior Project by Industry Advisors
- Evaluation of Senior Project by Faculty
- Writing Proficiency Exam (WPE)

ME

- ME 481 Senior Exam - administered in Winter and Spring Quarters
- Writing Proficiency Exam (WPE) - data from 2003-2008
- ME 318 Lab Final – administered in Fall, Winter and Spring Quarters
- ME 422 Lab and Lecture Final – administered in Fall, Winter and Spring Quarters
- ME 440 Parametric Study – administered in Fall, Winter and Spring Quarters
- ME 428 Oral Presentations – administered in Spring 2005, Winter 2007, Fall 2008, and Winter 2008
- Fundamentals of Engineering Exam Results – data from 2001 through 2007
- ME 463 Code of Ethics Assignment – Winter 2008
- ME 463 Ethical Case Study Evaluation – Winter 2008
- ME 463 Ethical Case Study Oral Presentations – Fall 2007 and Winter 2008
- ME 212 Embedded Exam Question – Spring 2005
- ME 212 Embedded Homework Problem – Fall 2005
- ME 212 Embedded Exam Question – Fall 2005
- ME 328 Embedded Exam Question – Fall 2005
- ME 343 Embedded Exam Question – Spring 2007
- ME 341 Diagnostic Test – Spring 2005
- ME 461/ME 462 IAB Review of Senior Project Reports – Spring 2005, Spring 06
- ME 481 Review of Senior Project Reports – Winter and Spring Quarters annually
- ME 463 Diagnostic Test – Fall 2005
- Senior Surveys – Winter and Spring Quarters annually
- Employer Survey –Winter and Spring 2006
- Industrial Advisory Board (IAB) Survey – Fall 2005

Appendix IV. Assessing and Evaluating Culminating Experiences

The following examples describe assessment instruments, as well as evaluation criteria. To evaluate the sufficiency of student performance, faculty members establish desired targets for each assessment measure (3.0 on a scale of 5). Also note that dates were included in many cases. This gives a feel for the sustained duration of many of the efforts.

After applying the threshold criteria indicated below, the results (either Above, Below or On-Target) can be readily pooled.

AERO

CRITERIA 3 (a-k) & l

AERO Program graduates demonstrate outcome by:	Senior Design	Senior Project	IAB Evaluation of Senior Projects	Senior Portfolio
a) ability to apply knowledge of mathematics, science and engineering	3.0	3.0		
b) ability to design and conduct experiments, as well as to analyze and interpret data	3.0	3.0	80%	
c) ability to design a system, component, or process to meet desired needs	3.0	3.0	80%	
d) ability to function on multi-disciplinary teams	3.0			80%
e) ability to identify, formulate and solve engineering problems	3.0			
f) understand professional and ethical responsibility	3.0	3.0		
g) ability to communicate effectively	symposium (separate grade) 3.0	report (separate grade) 3.0		80%
h) the broad education necessary to understand the impact of engineering solutions in a global and societal context	3.0	3.0		
i) a recognition of the need for, and an ability to engage in life-long learning			80%	
j) knowledge of contemporary issues	3.0		80%	80%
k) ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	3.0		80%	80%
l) ability to integrate aerospace knowledge into design competence	3.0	3.0	80%	80%

CE

Assessment Method	Constituent Group	Date(s)	Indirect or Direct Measure Description
Senior Design Project Evaluations	Faculty and Practitioners	2006-2008	Participants typically included 5 faculty and 8 practitioners who evaluated Senior Design work during each of the past three years. The participants evaluated written project reports and oral presentations. Rubrics and normalizing procedures were employed as part of the evaluation process. *(Direct)*
Senior Design Assignments and Exams	Graduating CE Seniors	2006-2008	Students enrolled in Senior Design are asked to complete homework assignments, in-class assignments, and final examinations, in addition to the design project. Graded assignments and embedded test questions were used to assess student achievement of different outcomes. *(Direct)*
Course Assignments and Exams	Current CE Students	2004-2008	Student performances on homework, projects, and embedded test questions were periodically assessed in several required undergraduate civil engineering courses. Results were used to evaluate the achievement of different outcomes. Grading rubrics were used when applicable. *(Direct)*
Extracurricular Projects	Current CE Students	2003 - 2008	In addition to in-class work, many civil engineering students participate in design projects coordinated through department student organizations. Student performances during design projects and competitions were used as indirect measures of student achievement for several outcomes. *(Indirect)*
FE Examination	Junior and Senior CE Students	2003 - 2008	FE exam scores were collected and summarized annually. Data analysis focused on subject area scores as well as overall pass rates as reported by NCEES for Cal Poly civil engineering students. Cal Poly scores were compared with National averages to evaluate student achievement. *(Direct)*

CE – Evaluation Criteria

- Students should score an average of 70 percent or higher for the different grading categories associated with the Senior Design project reports and presentations.

- Student design abilities, as directly assessed by faculty and practitioner evaluators in Senior Design, should be rated as "good" or better by at least 80 percent of the evaluators.

- Students should score an average of 60 percent or higher on graded homework problems, lab assignments, embedded test questions, and written reflection exercises. This score is similar to cut scores implemented for civil engineering exams sponsored by NCEES.

- Students should score an average of 50 percent or higher on graded final exam problems in Senior Design. A lower bar is used for this case given the relatively high emphasis that is placed on the project reports and presentations in the Senior Design course. A lower emphasis is placed on the examinations in the final grading formula.

- Student scores in all categories on the FE exam should be at or above the reported National averages. Average scores for the different categories should be 50 percent or higher.

CPE

Outcome	Course Assignment	When	Average Score	Threshold Score	Meet Threshold
3A	CPE 315 MT or ? Problem				
3B	CPE 450 System test assignment	W08-01	81%	75%	100%
3C.1	CPE 450 Final report	S06-01	87%	75%	100%
		S06-02	90%	70%	100%
		W08-01	87%	75%	100%
3C.2	CPE 350 Level N design assignment	W08-01	84%	70%	100%
3D.1	CPE 350 Teaming exercise	F07-01	100%	70%	100%
		W08-01	100%	70%	100%
3D.2	CPE 350 Team process assignment	F07-01	100%	70%	100%
		W08-01	91%	70%	100%
3D.3	CPE 450 Peer evaluation	S06-01	74%	70%	73%
		S06-02	74%	70%	65%
		W08-01	73%	70%	100%
3E	CPE 315 MT or ? Problem				
3F	CPE 329 Final Exam Problem (Essay)	W07-01	27%	60%	7%
		F07-01	78%	70%	71%
3G.1	CPE 450 Technical white paper	S06-01	74%	70%	70%
		S06-02	80%	70%	86%
		W08-01	77%	75%	94%
3G.2	CPE 450 Technical presentation	S06-01	88%	70%	100%
		S06-02	85%	70%	100%
		W08-01	75%	60%	94%
3H	CPE 350 Reflection	F07-01	73%	70%	75%
3I	CPE 450 Technical white paper	S06-01	74%	70%	70%
		S06-02	80%	70%	86%
		W08-01	77%	75%	94%
3J	CPE 350 Reflection	F07-01	73%	70%	75%
3K					
9L	CPE 315 MT or ? Problem				
9M	EE 228 MT or ? Problem				
9N	CPE 315 MT or ? Problem				

(*) ‘MT or ? Problem’ refers to either a question on a midterm or a homework problem.

CSC

Instrument	Timing of Effort	Artifact Collected	Means of Collection	Use of Artifact
Senior project archival	An ongoing effort	Work performed by student for senior project, including documentation and code files.	Upon completion of project, a student submits a CD containing all relevant files. These CDs are available from the department office.	It is the department's plan to have the projects reviewed by an independent source such as the IAC

Senior Project Analysis – EE (A Self-Evaluation by the Student)

ANALYSIS OF SENIOR PROJECT DESIGN

Please provide the following information regarding your Senior Project and submit to your advisor along with your final report. Attach additional sheets, for your response to the questions below.

Project Title:

Student's Name:	**Student's Signature:**

Advisor's Name:	**Advisor's Initials:**	**Date:**

- **Summary of Functional Requirements**
  Describe the overall capabilities or functions of your project or design. Describe what your project does. (Do *not* describe how you designed it).

- **Primary Constraints**
  Describe significant challenges or difficulties associated with your project or implementation. For example, what were limiting factors, other issues that impacted your approach? What made your project difficult? What parameters or specifications limited your options or directed your approach?

- **Economic**
- Original estimated cost of component parts (as of the start of your project).
- Actual final cost of component parts (at the end of your project)
- *Attach a final bill of materials for all components.*
- Additional equipment costs (any equipment needed for development?)
- Original estimated development time (as of the start of your project)
- Actual development time (at the end of your project)

- **If manufactured on a commercial basis:**
- Estimated number of devices to be sold per year
- Estimated manufacturing cost for each device
- Estimated purchase price for each device
- Estimated profit per year
- Estimated cost for user to operate device, per unit time (specify time interval)

- **Environmental**
- Describe any environmental impact associated with manufacturing or use.

- **Manufacturability**
- Describe any issues or challenges associated with manufacturing.

- **Sustainability**
- Describe any issues or challenges associated with maintaining the completed device, or system.
- Describe how the project impacts the sustainable use of resources.
- Describe any upgrades that would improve the design of the project.
- Describe any issues or challenges associated with upgrading the design.

- **Ethical**
- Describe ethical implications relating to the design, manufacture, use, or misuse of the project.

- **Health and Safety**
- Describe any health and safety concerns associated with design, manufacture or use of the project.

- **Social and Political**
- Describe any social and political concerns associated with design, manufacture or use.

- **Development**
- Describe any new tools or techniques, used for either development or analysis that you learned independently during the course of your project.

Senior Project Analysis - EE

As part of the requirement to complete a senior design project, the primary culminating experience of their degree program, each student must prepare and submit a report addendum that includes their "Analysis of Senior Project Design". Each senior project student completes this analysis, and submits it alongside their final project report in order to receive a grade for the project course. The student analysis sets their project in the context of a commercial product, and asks the student to assess its manufacturability and costs, as well as the potential impacts of its design, manufacture, or use, in such categories as environmental impacts, sustainability challenges, ethical issues raised, health and safety concerns, and social or political implications. The analysis also requires students to identify the constraints and challenges they encountered in completing this major design experience. Finally, it also focuses students' attention on the skills they may have exercised that support ongoing learning and life-long education, and provides a means of assessing the degree to which students have demonstrated this skill as part of the project. For this, we ask students what new design or analysis methods, tools, or techniques they had to *independently* learn in order to complete their Senior Project.

Students' responses in the project analyses they turned in were ranked as either 'Best', 'OK' or 'Poor' using the following rubric:

Best – Provide an example or a description of issue(s) with clear explanation pertaining to the question asked.

OK – Provide an example, but with no discussion or explanation; or a non-specific aspect, or general quality.

Poor – Provide no answer, or irrelevant answer, or 'Not Applicable' answer without explanation.

Since this is the first time in our accreditation cycle that we conducted the analysis, we used the 50% threshold as our baseline for satisfactory performance in the program outcomes addressed within the analysis.

Results of Senior Project Analysis - EE

Question	Outcome	Percent of Responses		
		Best	OK	Poor
Describe the overall capabilities or functions of your project or design	3e	75.0%	16.7%	8.3%
Descericbe significant challenges or difficulties associated with you project or implementation	3c	86.7%	11.7%	1.7%
Economic	3c	45.0%	45.0%	10.0%
Environmental Impact	3h	51.7%	16.7%	31.7%
Manufacturability	3c	48.3%	30.0%	21.7%
Sustainability	3j	65.0%	20.0%	15.0%
Ethical	3f	35.0%	20.0%	45.0%
Health & Safety	3h	41.7%	23.3%	35.0%
Social and Political	3h	33.3%	13.3%	53.3%
Development	3i	73.3%	1.7%	25.0%

ENVE

The ENVE Program didn't use any measures associated with senior project.

IE & MfgE (Similar processes and specifics for each program)

During the second course (IME 482) of the senior project sequence, students are requiredto give an oral presentation of progress and results to faculty and advisory board members. An evaluation form with a scoring rubric is used to judge the presentations on several dimensions corresponding to program outcomes. After IME 482, the students' written reports are also subject to advisory board review and documented evaluations. Average scores of 3.0 or better are considered the minimum acceptable for this assessment tool. Both the oral presentation and written evaluations involve data used to assess outcomes (c), (e), (g), and (k). The written evaluations are also used for assessment of outcome (i) based on the literature review component.

Data from the review of oral presentations on senior project during IAB Meeting Spring 2007 (IE & MfgE majors mixed, N≈9)

Criteria	Average Quality (1 to 5)
Student has identified and defined a suitable problem (e)	4.0
Student has solved the problem using an appropriate strategy (i.e.,the engineering design process) (c, e)	3.6
Student has used appropriate techniques, skills, or tools for the project (i.e., based on knowledge and skills acquired in course work) (k)	3.9
Student has assessed the economics of the project (c)	3.2
Student shows an ability to communicate effectively. (g)	3.7

Data from the review of written reports includes:
IAB Review (MfgEs)
FA07 (N=8)

Senior Project Report Evaluations
(Avg,out of 5)

Does the senior project have analysis to support design? (a, c) 4.38
Does the senior project consist of a design, build, and test (c, e) 3.88

Does the senior project consist of thorough literature review? (i) 4.50
Does the senior project demonstrate the ability to communicate effectively? (g) 4.13

Does the senior project demonstrate the ability to use techniques, skills and modern engineering tools necessary for engineering practice? (k) 4.50

A set of comments from IAB members were collected in spring 2008 after members had sat through and evaluated a new batch of senior projects. The comments include:

"I wanted to send off a quick note describing how impressed I was with the senior projects that were presented at the last IAB meeting. Each student clearly walked through problem and solution. I was particularly impressed with their ability to field questions without hesitation in their answers. That shows me that they were not only prepared but confident in the approach and methods (i.e. they understood how and why to apply a certain methodology). . . . I personally like the format that was used also (i.e. very time boxed). This is how (particularly early in their careers) their interaction will be with senior executives. They may get 5 minutes to pitch their "project" to receive approval, funding, etc. Again, each of the students achieved this and were able to answer quick direct questions. . . . Keep up the good work and I look forward to next group. "

"I would like to echo [these] comments regarding the Senior Project presentations we received last week. Our IAB group saw ~8 presentations and each student was very well prepared and they all presented their project confidently. I have participated in a number of Senior Project reviews - this was easily the best combination of work quality and presentation that I have seen. I was very impressed with the projects that they selected. Most of them addressed a real industry need, requiring the students to develop and manage a customer relationship. . . . I also had a chance to review a written Senior Project and was equally as impressed with the scope and quality of work - it also involved work for a direct industry client... You should be proud of what your students are accomplishing!

"I totally concur with the observations. This format is definitely more conducive to the elevator speech project summary and requires the student's to be able to talk to key important aspects of their projects. I also agree the subjects selected seemed appropriate and on track."

"[I] Agree. I was talking to a few students after and they all thought it was a good exercise, esp the ones that have been on co-ops/internships. They recognized that this is what industry is like and need to be prepared for it. For those that weren't prepared, they felt it a bit more but are better because of it. They now know what to expect and will be better the next time."

"I feel this approach is definitely better than what we had done in the past... where we had each student make up poster boards outlining their Sr. Project and the IAB members would go around individually and review at least 4-5 projects. This new approach gives the student(s) the opportunity to concisely present their projects

like they would do in industry. It also makes better use of our time by seeing and critiquing more projects."

The data from the oral and written evaluations of the senior project presentations and written reports is very positive. All evaluations are well above the 3.0 threshold of acceptability. The scores for problem-solving (e), design (c), analysis (a), communication (g), literature review (i), and techniques/skills (k) are all quite high, averaging over 4.0. The comments from spring 2008 all reflect very highly on the student's problem-solving (e) and communications (g) skills. The weakest evaluation scores are those dealing with an economic analysis of the project. This is considered related to Outcome c (Design) since it is the economics that is used as design criteria to justify the design change in most cases. Improving this aspect of the projects may be an important improvement opportunity related to design skills in the years to come.

Evaluation of Outcome C on Design Ability

3c) Students will attain *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* (includes process, assembly and product engineering: understanding the design of products and the equipment, tool, and environment necessary for their manufacture; manufacturing systems design: understanding the analysis, synthesis, and control of manufacturing operations using statistical and calculus based methods, simulation and information technology)

• Alumni and industrial advisory board members both agree that Design (3c) is one of the more important outcomes (ranked 4th by both constituencies with a composite importance rating of 4.26 out of 5).

• Advisory board members judge this outcome to be achieved by graduates at an acceptable level (4.0 out of 5). The level is also considered appropriate by the IAB based on its relative importance as an outcome.

• Employers of MfgE graduates also see Design as being achieved at an acceptable (3.94) and appropriate (4.05 for importance) level. Process improvement, 3-D modeling, cost analysis, tool design, and manufacturing systems design are considered to be the most desirable skills.

• Senior exam scores related to this outcome are at an acceptable level (71.7% correct). Given its relative importance, the scores are considered appropriate.

• Graduating seniors consistently rate their level of attainment of this outcome as acceptable (3.67), but slightly lower than other constituencies, and slightly lower than its importance might warrant.

• Graduating seniors also appear satisfied with their design experience since no significant comments have been made during senior interviews regarding any deficiency in design skills or knowledge.

• Senior project evaluations (both oral and written) related to design skills are almost entirely positive, with ratings generally above 4.0 out of 5. One weakness noted often is the lack of sufficient economic analysis used in justifying the students' designs.

Based on these findings, this outcome appears to be achieved at an acceptable level since all of the assessment tools lead to this same conclusion. Potential improvement opportunities exist in raising graduating students' assessment of their own design skills and improving the economic justification used in senior projects. In general faculty believe that our students meet the necessary minimum requirements for Design, and that continuous improvement efforts are better focused elsewhere.

ME

Senior Project Report – Used to Evaluate Design Skills

During the IAB meeting on May 13 and May 14, 2005, nineteen senior project reports were assessed by the IAB members and the faculty. Each senior project report collected from the faculty was assigned a unique number; however, not all of the reports collected were reviewed. The senior project reports were randomly selected from the projects that were submitted during academic year 2004-2005. A scoring rubric, Appendix F-7, was used by the IAB members and faculty to perform the assessment. Questions 1 and 2 on the rubric pertained to design. The assessment was scored on a scale from 1 to 6 with 1- unacceptable, 3-acceptable, and 6-best. The faculty set 'Acceptable' (a score of 3) as the minimum performance criteria on this rubric. For Question 1, which assessed the students' ability to use analysis, the average score was 4.2 out of 6 or 70%. For Question 2, which assessed the students' ability to develop a design solution, the average score was 4.9 or 82%.

During the IAB meeting on May 19 and May 20, 2006, 10 senior project reports were assessed by the IAB members and the faculty. The assessment was performed on senior project reports from the 2005-2006 academic year under the new senior design/senior project class in which students worked in small groups. The same scoring rubric and minimum performance criteria were used as the previous year. The average score on Question 1 was 5.2 or 87% and the average score on Question 2 was 85%.

In March 2007, based on comments from faculty and the IAB members, the senior project scoring rubric was modified. The new rubric, included in Appendix F-7, was used to evaluate the senior project reports from the 2006-2007 academic year. The assessment was scored on an expanded scale from 1 to 6 with 1-unacceptable, 2-poor, 3-marginal, 4-acceptable, 5-proficient, and 6-exemplary. The faculty set 'Marginal' (a score of 3) as the minimum performance criteria on this rubric. The number of questions on the rubric was expanded to 8 to better assess the students' design skills.

The following five questions from the rubric were used to assess Criterion 3 (c), Skills
1, 2, and 3:

Question 1: Did the students develop appropriate design specifications (Skill 1)?
Question 2: Did the students review state-of-the-art and use appropriate technical resources (Skills 1 and 2)?
Question 3: Did the students adequately explore potential solutions (Skill 2)?
Question 4: Did the students develop a design solution based on the specifications including drawings and schematics (Skill 2)?
Question 5: Did the students use analysis to refine their design (Skill 3)?

Senior project reports were assessed by the faculty, class instructors, and the industry sponsors. The table below contains the results of their assessment. The count represents the number of projects each group evaluated. Based on the comparison between 2004-2005 and 2005-2006 the change in senior design/senior project to small groups from individual projects resulted in an improvement in the quality of the senior project report. Based on the results from 2006-2007 and 2008, no significant deficiencies were noted.

Senior Design Oral Presentations

As part of senior design/senior project, the students are required to make an oral presentation to the industry sponsors and faculty. The scoring rubric in Appendix F-8 was used to score the oral presentations. On the design related questions, the oral presentation was scored out of 20 points where a score of 14 was set as the minimum expected performance. In Spring 2005, eleven evaluations were completed by our industry sponsors. The average score was 17.8 out of 20 or 89%, which is acceptable. In Winter 2007, twenty-two evaluations were completed by our industry sponsors and faculty. The average score was 17.8 out of 20 or 89%, which is acceptable. In Fall 2007, twenty-one evaluations were completed by our industry sponsors and faculty. The average score was 18.4 out of 20 or 92%, which is acceptable. In Winter 2008, twenty one evaluations were completed by our industry sponsors and faculty. The average score was 18.4 out of 20 or 92%, which is also acceptable.

Project Name:_____ Reviewer:_____

ME 481: Senior Project Rubric Date:_____

Characteristic	**Exemplary (6)**	**Proficient (5)**	**Acceptable (4)**	**Marginal (3)**	**Poor (2)**	**Unacceptable (1)**	**N/A**
Did the students develop appropriate design specifications?							
Did the students review state-of-the-art and use appropriate technical resources?							
Did the students adequately explore potential solutions?							
Did the students develop a design solution based on the specifications including drawings and schematics?							
Did the students use analysis to refine their design?							
Did the students build a functional prototype?							
Did the students test its performance?							
Did the students write an effective report that was clear, well-organized, and free of grammatical errors?							

Did the students develop appropriate design specifications?

EXEMPLARY (6 points): Students developed thorough, logical, and complete design specifications; insightful.

PROFICIENT (5 points): Students developed sound and complete design specifications but may not be as insightful as an exemplary report.

ACCEPTABLE (4 points): Students developed generally accurate design specifications but may be lacking in completeness.

MARGINAL (3 points): Students developed some design specifications but is lacking in significant areas.

POOR (2 points): Students developed few design specifications and failed to demonstrate understanding of the design specifications as it relates to the project.

UNACCEPTABLE (1 point): Students demonstrated no ability to develop specifications.

Did the students review state-of-the-art and use appropriate technical resources?

EXEMPLARY (6 points): Quality of references and standards show superior insight.

PROFICIENT (5 points): Use of references is complete, but may not be as insightful as an exemplary report.

ACCEPTABLE (4 points): Appropriate references and standards listed, but may be lacking in completeness.

MARGINAL (3 points): References not specific and are lacking in significant areas.

POOR (2 points): Some references not cited or standards omitted. Students failed to use appropriate resources.

UNACCEPTABLE (1 point): Students failed to review state-of-the-art or use technical resources.

Did the students adequately explore potential solutions?

EXEMPLARY (6 points):	Students explored thorough ideation and consideration of alternate designs.
PROFICIENT (5 points):	Students explored alternative solutions but may not be as thorough as an exemplary report.
ACCEPTABLE (4 points):	Students explored some potential solutions.
MARGINAL (3 points):	Students explored some potential solutions but not in detail.
POOR (2 points):	Students explored few potential solutions but failed to adequately discuss them.
UNACCEPTABLE (1 point):	Students failed to explore other potential design solutions.

Did the students develop a design solution based on the specifications including drawings and schematics?

EXEMPLARY (6 points):	Students developed thorough, logical, and complete design solution; insightful, innovative, and creative.
PROFICIENT (5 points):	Students developed sound and complete design solution but may not be as innovative as an exemplary design solution.
ACCEPTABLE (4 points):	Students developed a generally accurate design solution but may be lacking in completeness.
MARGINAL (3 points):	Students developed a design solution that is lacking in significant areas.
POOR (2 points):	Students failed to develop a design solution based on the specifications.
UNACCEPTABLE (1 point):	Students demonstrated no ability to develop a design solution.

Did the students use analysis to refine their design?

EXEMPLARY (6 points):	Students used analysis techniques in a logical, thorough, and innovative approach to support/modify their design.
PROFICIENT (5 points):	Students used analysis techniques in a sound and complete approach to support/modify their design; but may not be as innovative as an exemplary analysis.
ACCEPTABLE (4 points):	Students used analysis techniques to support/modify their design in a generally accurate approach but may be lacking in completeness.
MARGINAL (3 points):	Students used analysis techniques to support/modify their design that is lacking in significant areas.
POOR (2 points):	Students did not use analysis techniques to support/modify their design.
UNACCEPTABLE (1 point):	Students did not demonstrate an ability to use analysis techniques to support/modify their design.

Did the students build a functional prototype?

EXEMPLARY (6 points):	Students built a functional prototype according to the design. The prototype was well-built and professional in appearance.
PROFICIENT (5 points):	Students built a functional prototype according the proposed design. The prototype was well-built.
ACCEPTABLE (4 points):	Students built a functional prototype; but it may be lacking in completeness or professionalism.
MARGINAL (3 points):	Students built a prototype; some functionally evident, but lacking in completeness.
POOR (2 points):	Students did not build a functional prototype; prototype lacking in significant areas
UNACCEPTABLE (1 point):	Students did not build a prototype.

Did the students test its performance?

EXEMPLARY (6 points): Students tested the prototype against the proposed design. The testing was well-done with appropriate instrumentation and uncertainty analysis.

PROFICIENT (5 points): Students tested the prototype against the proposed design. Testing was completed with appropriate instrumentation and uncertainty analysis.

ACCEPTABLE (4 points): Some testing with a comparison to the proposed design was accomplished; but it may be lacking in completeness.

MARGINAL (3 points): Minimal testing was accomplished and it was lacking in significant areas.

POOR (2 points): Little or no testing was accomplished.

UNACCEPTABLE (1 point): No testing was accomplished.

Did the students write an effective report that was clear, well-organized, and free of grammatical errors?

EXEMPLARY (6 points): Students wrote well-organized, well-developed, thorough report. The report exhibited proficient sentence structure and usage, but may have a few minor slips (e.g. an occasional misused or misspelled word).

PROFICIENT (5 points): Students wrote an effective and thorough report. The report exhibited effective sentence structure and usage. Sound grammar is maintained, though may err occasionally.

ACCEPTABLE (4 points): Students wrote an adequate report. The report shows adequate command of sentence structure but may contain some minor errors in grammar, punctuation, or usage.

MARGINAL (3 points): Students wrote a report that lacks focus and is deficient in organization. The report shows deficient sentence structure or contains errors in mechanics including spelling which are serious or frequent enough to affect understanding.

POOR (2 points):	Students wrote a report is seriously flawed particularly in organization. Grammatical errors are so severe and pervasive that other strengths of the report are obscured.
UNACCEPTABLE (1 point):	Students wrote a report that shows virtually no ability to handle the topic. The report reveals an inability to handle basic elements of prose.

Appendix V. Program Improvements

Several of the following program improvements address issues with senior project. Others address broader issue. Most notable is the multifaceted criteria used to identify and prioritize changes. Multiple inputs from multiple sources are common. These program improvement decisions are not taken lightly.

Improvement Action #1	L	M	H
		✓	

Description of Action:

Developed a new required civil engineering course titled Numerical Methods in Civil Engineering (CE 251) which was designed to allow students to apply mathematical concepts to civil engineering problems using computational software (e.g. MATLAB). (2005)

Outcome(s):	1	2	3	4	5	6	7	8	9	10	11	12

Performance Metric(s): 1a,1b,1c,1e,11a,11c

Basis for Implementation:

- We helped streamline the curriculum by eliminating the numerical engineering analysis elective course (CSC 341), which was taken by approximately 40 percent of our students. The alternative to this course was engineering economics.
- The faculty members expressed concern regarding the students' mathematical abilities. Student performance on the FE exam was average in the mathematics category and below average in the computers category.
- Graduates of the civil engineering program must demonstrate an ability to use modern engineering tools, like spreadsheets and computational software.
- The faculty members wanted the students to be competent when using standard computational software so that this software could be used in follow-on civil engineering courses at the 300 and 400 levels.

Results of Implementation:

- All civil engineering students now receive formal instruction on the application of MATLAB to common civil engineering problems.
- Since the course was first offered we have observed a slight improvement in student performance on the math and computers parts of the FE examination.
- Students have expressed frustration with the course and have generally given below average evaluations to their instructors, regardless of the faculty member teaching the course.
- Although the process has been slow, more and more students and faculty are successfully using MATLAB and EXCEL as tools in follow-on courses.
- We realized that we had a limited number of faculty willing and able to teach this course. We are now recruiting at least one instructor from each technical emphasis area so that a teaching rotation can be established.
- We recently recommended that strength of materials be added as a prerequisite for this course so that students have additional problems that they can solve using MATLAB. This change will be implemented with the new catalog. (2009)

Comments:

- The CE 251 course was originally assigned 2 units and taught using 1 lecture and 1 laboratory per week; however, based on student and faculty feedback, the course is now assigned 4 units and taught using 3 lectures and 1 laboratory per week. The new unit total better reflects the workload associated with the course. (2007)
- The implementation of this course and acceptance by the students has been slow; however, it appears that the students' mathematics abilities are improving. We need to continue to collect assessment data to evaluate this improvement action.

Improvement Action #4	L	M	H
			✓

Description of Action:

Required that students in the Senior Design course work on 6-person multi-disciplinary teams to complete the assigned capstone design project. (2005)

Outcome(s):	1	2	3	4	5	6	7	8	9	10	11	12

Performance Metric(s): 4a,4b,4c,4d

Basis for Implementation:

- Graduates of the civil engineering program must demonstrate an ability to function on a multi-disciplinary team.
- A formalized, truly multi-disciplinary experience did not exist in the civil engineering curriculum, and a concern was raised during our last accreditation visit.
- The faculty members recommended that the students gain formal teamwork experience outside of the typical laboratory group setting.
- Faculty and IAB members recommended that the students be given more opportunities to develop their communication and teamwork abilities.

Results of Implementation:

- We established a baseline of student performance relative to multi-disciplinary teamwork by collecting considerable data during the new senior design offerings.
- We established grading rubrics and peer evaluation procedures so that faculty members, design practitioners, and students could assess teamwork abilities.
- Assessment results indicate that our students' ability to function on a multi-disciplinary team is exceptional.
- Graduating senior survey results indicate that our students are confident in their verbal communication and teamwork abilities.
- We developed focused learning modules that help train our students to become more assertive, to understand different communication styles, and to apply active listening techniques.

Comments:

- Our students are assigned to their teams based on their academic preparation, industrial experience, academic performance. The individual members of a team very often do not know their teammates prior to the start of the course. Although they are asked to work outside their "comfort zone," our students are still able to adapt and be successful.
- Assessment results from the Senior Design course are being used to inform decisions on curricular improvements related to Outcome 4.

AERO

Measurement Tool	Finding	Implementation
Senior Project	Need more connection to outcomes	Students added outcomes discussion to report
IAB evaluation of Senior Project	Need better evaluation and more relevant projects	Improved evaluation forms and added industry sponsored projects
Senior portfolio	Need for systems instruction	Added systems lecture to fall of senior design course

CPE

The introduction of the new two-quarter capstone sequence, CPE 350 and CPE 450, resulted from input by many CPE constituents – a noteworthy example of applying our continuous improvement cycle that continues to this day. Feedback from graduate, faculty, and our industrial advisory board presented the need for a significant real-world, team-based design experience. The capstone was designed to meet this need. It was first taught in Spring 2005.

EE

Program Improvement Related to Career Accomplishments ('Objectives')

The Objectives of the EE Program are for their graduates to:

1. Excel in the electrical engineering profession;
2. Embrace life-long learning as a necessary component to remain current in their profession; and
3. Pursue graduate degrees for enhanced skills and opportunities.

These career objectives target accomplishments 3-5 years after graduation.

Past surveys of seniors revealed that they were not well-informed regarding opportunities for grad school, and the benefits thereof. This was a serious shock to the program faculty!

Subsequently, a change was made to the program to add a lecture to a senior seminar course. The department's graduate advisor serves as a guest lecturer to discuss opportunities made available via advanced degrees.

ENVE

Materials and lectures will be added to existing courses to address several of the issues on the Senior and Alumni Surveys:

> ENVE 466 and 467 Senior Design – Additional lectures and guest speakers will be added to enhance the content of the following topics:
>
> Engineering Economics
> Construction Related Topics (bidding, construction management, negotiation, scheduling, contracts, professional liability insurance)

2. I.b. Please rate your understanding of:

	Poor	Fair	Good	Very Good	Excellent	Rating Average	Response Count
the ASCE Code of Ethics	8.3% (1)	8.3% (1)	**41.7% (5)**	25.0% (3)	16.7% (2)	3.33	12
ethical responsibility in engineering practice	0.0% (0)	16.7% (2)	16.7% (2)	25.0% (3)	**41.7% (5)**	3.92	12
professional responsibility in engineering practice	0.0% (0)	8.3% (1)	16.7% (2)	**41.7% (5)**	33.3% (4)	4.00	12
the impact that engineering projects have on natural resources	0.0% (0)	0.0% (0)	8.3% (1)	41.7% (5)	**50.0% (6)**	4.42	12
environmental regulations	8.3% (1)	0.0% (0)	16.7% (2)	**50.0% (6)**	25.0% (3)	3.83	12
environmental impact analysis	8.3% (1)	0.0% (0)	25.0% (3)	25.0% (3)	**41.7% (5)**	3.92	12
techniques for community consensus building on engineering projects	0.0% (0)	25.0% (3)	**33.3% (4)**	16.7% (2)	25.0% (3)	3.42	12
engineering economics principles	16.7% (2)	25.0% (3)	**33.3% (4)**	8.3% (1)	16.7% (2)	2.83	12
contemporary issues as they relate to my profession	0.0% (0)	16.7% (2)	25.0% (3)	25.0% (3)	**33.3% (4)**	3.75	12
contemporary issues as they relate to society	8.3% (1)	16.7% (2)	25.0% (3)	16.7% (2)	**33.3% (4)**	3.50	12
how engineering work is procured	8.3% (1)	8.3% (1)	**41.7% (5)**	25.0% (3)	16.7% (2)	3.33	12
bidding versus quality-based selection processes	16.7% (2)	25.0% (3)	**41.7% (5)**	8.3% (1)	8.3% (1)	2.67	12
how engineers interact with construction professionals	25.0% (3)	**41.7% (5)**	16.7% (2)	8.3% (1)	8.3% (1)	2.33	12
negotiation	16.7% (2)	**33.3% (4)**	**33.3% (4)**	0.0% (0)	16.7% (2)	2.67	12
project management and scheduling	8.3% (1)	16.7% (2)	**50.0% (6)**	16.7% (2)	8.3% (1)	3.00	12
engineering contracts	**33.3% (4)**	25.0% (3)	**33.3% (4)**	0.0% (0)	8.3% (1)	2.25	12
professional liability insurance	33.3% (4)	8.3% (1)	**50.0% (6)**	0.0% (0)	8.3% (1)	2.42	12
risk management	25.0% (3)	0.0% (0)	**41.7% (5)**	16.7% (2)	16.7% (2)	3.00	12
					answered question		**12**
					skipped question		**0**

Evaluation of Graduating Senior Surveys by ENVE Program

The surveys are an indirect measure of Outcomes but are nonetheless valuable to provide feedback to the faculty on Curriculum and other issues. The College of Engineering has greatly facilitated the survey process by developing an online standardized survey instrument that provides useful statistical information. This survey tool was first used this year in the Winter 2008 ENVE 467 Senior Design course.

The sample set for the survey was abnormally small in the 2007 – 2008 graduating class. Normally our graduating class in 25 to 30 students. We can to some extent forecast this based on enrollments in certain "indicator" courses. This year's class was only 13 graduates, with 12 students taking the survey. This is too small to be statistically valid, but will provide some general trends.

The results of the entire survey is attached to the Self Study as Appendix G. Key results are presented in the following Tables. The survey is keyed to ABET Outcomes on a 1 to 5 scale (Poor = 1, Excellent = 5). Results less than a 3 (Good) are items of concern.

Overall the results of the survey (Table 4-3 to 4-7) show that Environmental Engineering students are pleased with their education at Cal Poly. Only a few responses had an average rating at or below 3.0 :

- Probability and Statistics
- Using CAD Software
- Engineering Economics
- Construction Related Topics (bidding, construction management, negotiation, scheduling, contracts, professional liability insurance)

IE & MfgE (Similar Styles and Approach)

3c) Students will attain *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* (includes ability to design and develop integrated systems that include people, materials, information, equipment and energy)

• Alumni and industrial advisory board members both agree that Design (3c) is one of the more important outcomes (ranked 4th by both constituencies with a composite importance rating of 4.30 out of 5).

• Advisory board members judge this outcome to be achieved by graduates at an

acceptable level (4.02 out of 5). The level is also considered appropriate by the IAB based on its relative importance as an outcome.

• Employers of IE graduates also see Design as being achieved at an acceptable (3.83) and appropriate (4.08 for importance) level. Process improvement, 3-D modeling, cost analysis, tool design, and manufacturing systems design are considered to be the most desirable skills.

• Senior exam scores related to this outcome are at an above average level (76.61). Given its relative importance, the scores are considered appropriate.

• Graduating seniors consistently rate their level of attainment of this outcome as acceptable (3.80), but slightly lower than other constituencies, and slightly lower than its importance might warrant.

• Graduating seniors also appear satisfied with their design experience since no significant comments have been made during senior interviews regarding any deficiency in design skills or knowledge.

• Senior project evaluations (both oral and written) related to design skills are almost entirely positive, with ratings generally above 4.0 out of 5. One weakness noted often is the lack of sufficient economic analysis used in justifying the students' designs.

Based on these findings, this outcome appears to be achieved at an acceptable level since all of the assessment tools lead to this same conclusion. Potential improvement opportunities exist in raising graduating students' assessment of their own design skills and improving the economic justification used in senior projects. In general faculty believe that our students meet the necessary minimum requirements for Design, and that continuous improvement efforts are better focused elsewhere.

Improvement Area #3: Senior Project Guidelines, Responsibilities and Content

Opportunity:
• Variability of senior project quality (faculty input)
• SP is too time consuming for faculty-should it be drastically changed toward team projects (faculty input)
• Inconsistency regarding whether co-op and internship projects can be used for SP (negative comments from senior exit interviews Sp06 and Sp07)
• Variability of number of students allowed on a single SP may be unfair (negative comments from senior exit interviews Sp06 and Sp07)

Responsible Party: Tali Freed (Chair), Roya Javadpour, Liz Schlemer, Dan Waldorf, and Don White

Root Causes:

- Lack of up-to-date guidance on website
- Lack of list of minimum content requirements
- Inconsistent teaching and advising among the faculty; unbalanced advising load among faculty
- Lack of good sample senior project library
- Lack of decision on presentations vs. poster session
- Lack of funding for senior project

Planned Activities and approximate timeline:

Action #1. Website guidelines revised on paper (Schlemer; May 2007)
Action #2. Website guidelines to be revised on website (Originally assigned to Javadpour in May 2007; Later changed to Schlemer; January 31, 2008)
Action #3. Recommendation made to faculty regarding SP supervision, max number of students, and co-op/ internship reached (Freed: May 2007)
Action #4. Sample SP library to be organized and clearly marked (Freed; January 31, 2008)
Action #5. Minimum content requirements verified by instructor (Javadpour & Schlemer; March and June 2008)
Action #6. Presentation of SP to IAB (Javadpour or Schlemer; May 2008)

Actions Completed:

Action #1. Website guidelines revised on paper (Schlemer; May 2007)
Action #2. In progress
Action #3. Decision reached: SP supervision remains as today - by individual faculty, and submission of parts organized by course instructor; IME senior project is not a team project (May 2007); senior project max number of students is 2 (May 2007); co-op/ internship projects can be used for SP as long as format and components of SP are appropriate (May 2007)
Action #4. In progress
Action #5. List of Essential SP Content Components developed (Freed & White; September 2007)

i. Content – Essential components

1. Literature Review – at least 10 non-internet references, i.e., books and refereed journal articles
2. Engineering economics consideration & cost/benefit analysis
3. Project management
4. Existing vs. proposed solution
5. Design component

ii. Writing quality must be enforced and is the student responsibility

• Action #6. Decision reached and performed: SP presentation to IAB required in November and May (Schlemer; November 2007)

Evidence of Improvements:
• IAB evaluation of senior projects reviewed in May 2008 showed a notable improvement. These comments are listed under Criterion 3 as evidence from the IAB reviews of senior projects that students are attaining the problem- solving and communications Outcomes. An example comment is presented below:

"[I was] impressed with the senior projects that were presented at the last IAB meeting. Each student clearly walked through problem and solution. I was particularly impressed with their ability to field questions without hesitation in their answers. That shows me that they were not only prepared but confident in the approach and methods (i.e. they understood how and why to apply a certain methodology). . . . I personally like the format that was used also (i.e. very time boxed). This is how (particularly early in their careers) their interaction will be with senior executives. They may get 5 minutes to pitch their "project" to receive approval, funding, etc. Again, each of the students achieved this and were able to answer quick direct questions. . . . Keep up the good work and I look forward to next group."

This improvement effort will continue to be monitored, and the team will particularly be looking to see if fewer negative comments are made about the senior project experience in the senior survey and senior exit interview.

MATE

To foster professionalism, we have redesigned our senior seminar/senior project series (MATE481-484). We have converted our senior seminar course (481) from the typical "how to apply for a job" lectures to a substantial, activity-based course that prepares students for the corporate engineering environment. This course, designed by Savage, is based on his 20+ years in the industry. It has received rave reviews by our External Advisory Board members. We have also converted our senior project (482-484) into a guided experience that more closely resembles real-world project management. A key feature of the final senior project course (484) is that the students present their projects in a professional conference setting. We are teaching (and using) a new approach to engineering presentations described by Alley (Alley, 2001). This revolutionary approach emphasizes graphical means (images) to communicate ideas and de-emphasizes the use of bulleted lists. Although Alley's method takes us all outside our comfort zone, the results are amazing; after seven hours of presentations, our EAB members were so impressed that at least one reworked the presentation that he was to give in the following week. Incidentally, we are happy to report that we have gone from a 60-90% senior project completion rate to a 100% *on time* completion rate *for six consecutive years*.

Appendix VIa. Defining Career Accomplishment for Graduates

CE

- Successfully perform essential engineering functions in civil engineering practice;
- Communicate effectively with industry professionals and community members;
- Work in a professional manner to positively impact the environment and society;
- Pursue life-long learning through continuing education opportunities, graduate degrees, and/or other professional certifications; and
- Progress toward professional licensure.

CPE

- Make positive contributions to society and the practice of computer engineering by applying foundational knowledge and the engineering process to solve engineering problems.
- Work in an individual or team environment in a socially responsible manner.
- Engage in lifelong learning through continued professional development or graduate studies.
- Communicate effectively and demonstrate leadership.

CSC

- Are successful professionals, and, if they desire, are prepared to pursue graduate study.
- Have a broad knowledge of computer science and substantial knowledge of at least one key area of computer science.
- Think independently, acquire knowledge, and continue their development as professionals.
- Apply scientific and engineering methodology to the design, implementation, analysis, and evaluation of computer-based systems.
- Communicate effectively, both orally and in writing, and collaborate effectively in teams.
- Are prepared for the ethical, societal, and global issues associated with the computing field.

EE

- Excel in the electrical engineering profession;
- Embrace life-long learning as a necessary component to remain current in their profession
- Pursue graduate degrees for enhanced skills and opportunities.

ENVE

• Practice as professional engineers by gaining a thorough foundation in water and wastewater, air pollution, and solid and hazardous wastes.
• Pursue higher studies, research and life-long learning, and develop an appreciation of liberal arts and social sciences.
• Have a global awareness of environmental issues and use appropriate technologies to solve them.

IE

- *Immediate Practice* – Graduates will make immediate contributions to the practice of industrial engineering or a related field by providing knowledge of contemporary issues and direct, hands-on experience with the modern tools and techniques of the discipline.
- *Solid Engineering Foundations* – Graduates will have successful careers based on their ability to solve problems and make improvements through engineering design, experimentation, and application of scientific principles as well as their ability to analyze and critically evaluate their decisions.
- *Broad Education* – Graduates will have careers of distinction and leadership based on their ability to communicate effectively, to contribute meaningfully to a team effort, and to understand the economic, societal, and ethical impacts of their decisions.
- *Life-long Learning* – Graduates will demonstrate the ability and desire to follow a life-long pursuit of personal fulfillment through education.

MfgE

Same as for IE, except with 'industrial' replaced with 'manufacturing '

MATE

- Apply materials engineering principles to analyze and solve real-world engineering challenges.
- Communicate and perform as effective engineering professionals in both individual and team-based project environments.
- Develop intellectually through continuous learning.
- Work in an individual or team environment in a socially responsible manner.

ME

- A Mechanical Engineering graduate will be able to research, design, develop, test, evaluate, and implement engineering solutions to problems that are of a complexity encountered in professional practice.
- A Mechanical Engineering graduate will be able to communicate and perform as an effective engineering professional in both individual and team-based project environments.
- A Mechanical Engineering graduate will consider the ethical implications and societal impacts of engineering solutions.

- A Mechanical Engineering graduate will continuously improve through lifelong learning.

SE

Three to five years after graduation, Software Engineers

- Are successful professionals; some have successfully pursued graduate study
- Can apply the software engineering body of knowledge to software intensive projects
- Can design and implement improvements in their organization's software processes

Appendix VIb. Assessing Career Accomplishment of Graduates

Educational Objective	Measurements Used in Our Assessments (Note that "graduate" = alumnus 2 to 5 years removed from Cal Poly)
Success in Practice	Graduates given management/leadership responsibilities Graduates promoted above an entry-level position Graduates make positive contributions with minimal supervision Graduates transition from college to industry in a timely fashion Employers satisfied with quality of graduates work Graduates exhibit strong problem solving and design abilities Graduates demonstrate the ability to make decisions Graduates demonstrate the ability to set and achieve goals
Work Effectively with Others	Graduates demonstrate the ability to work on a team in practice Graduates demonstrate the ability to listen Graduates demonstrate the ability to communicate in writing Graduates demonstrate the ability to communicate orally Graduates demonstrate the ability to communicate with other professionals
Responsible Professionals	Graduates are members of professional organizations Graduates subscribe to technical journals and/or trade magazines Graduates attend conferences and/or workshops Graduates pursue continuing education opportunities Graduates are ethically responsible Graduates practice sustainable design principles in their work Graduates keep updated on current environmental regulations Graduates recycle and practice energy conservation Graduates volunteer for community service Graduates understand global, societal, and environmental design impacts
Seek Professional Licensure	Graduates are licensed civil engineering professionals Graduates are planning to become licensed professionals Graduates have passed the FE Examination Pass rates for the FE and PE examinations
Seek Advanced Studies in Civil	Graduates have earned or are earning an advanced CE degree

Engineering	Graduates are planning to earn an advanced CE degree Graduates have earned a license or certification (outside of the PE)
Well-Rounded Individuals	Graduates rely on a breadth of CE knowledge in practice Graduates rely on a breadth of GE knowledge in practice Graduates demonstrate knowledge of current issues Graduates demonstrate adequate reading habits Graduates have taught courses, workshops, or seminars

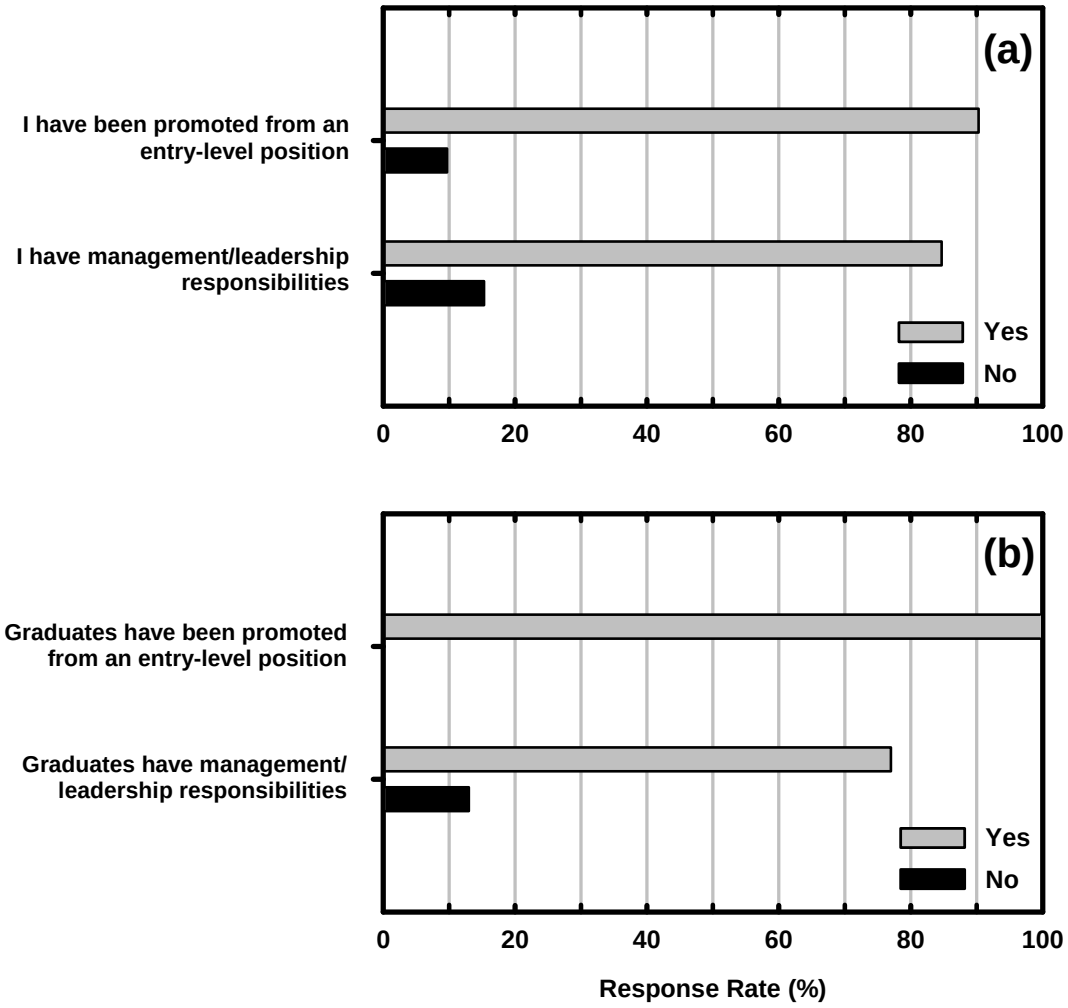

Figure 1 - Student success after graduation as assessed by (a) alumni; (b) IAB members.

Senior Project Project Report
College of Liberal Arts
Submitted by Debra Valencia-Laver
Fall 2011

PART II:
ASSESSING THE SENIOR PROJECT AS AN ARTIFACT OF STUDENT LEARNING

Five College of Liberal Arts majors, all undergoing program review in 2010-2012, took part in the direct assessment of their senior projects. Those majors were: Communication Studies (COMS), Child Development (CD) and Psychology (PSY – these are separate majors in one department), Philosophy (PHIL), and Theatre Arts (TH). The programs assessed senior projects on two learning outcomes: writing, using the University Writing Rubric, and critical thinking, using one of the VALUE rubrics designed to look at some aspect of critical thinking, either the Critical Thinking VALUE Rubric or the Inquiry and Analysis VALUE Rubric.

1. Did you modify the University Expository Writing Rubric?

College Summary:

Four programs (COMS, CD, PSY, PHIL) used the university's six-trait rubric, which examines the traits of Purpose, Synthesis, Support, Audience, Style, and Mechanics. Theatre Arts used the 5-point rubric that was supplied with the project. This rubric was modified to exclude Audience as an assessed trait as some earlier university research had indicated that establishing agreement on this trait had proved more difficult.

2. Please add your comments on the University Expository Writing Rubric including recommendations for improvement.

College Summary:

Only Communication Studies provided feedback on this item. Their response is as follows:

- **Communication Studies -** While a rubric that operationally defines each point on the scale helps assessors who have no idea what might characterize poor versus superior attainment with respect to a particular trait, the definitions force a transformation from continuous data to discrete data. In the process, assessors are left with projects that do not seem accurately characterized by the language of any of the points on the scale.

  The framing of the points on the support trait scale fit projects that involve largely argumentative writing, but pose problems for projects that are largely expository in nature.

These comments suggest that additional training on the use and potential modification of the writing rubric may be helpful to departments who are considering its use.

3. Did you modify the Critical Thinking VALUE Rubric?

College Summary:

None of the three programs (COMS, PHIL, TH) that used the Critical Thinking VALUE Rubric modified it for this project.

4. Did you use a different critical thinking rubric?

College Summary:

Psychology and Child Development chose to use the Inquiry and Analysis VALUE Rubric, which was seen to be a better fit for the range of projects produced in the department. The rubric was used as is.

5. Please add your comments on the Critical Thinking VALUE Rubric including recommendations for improvement.

College Summary:

Only Communication Studies provided feedback on this item. Their response is as follows:

- **Communication Studies -** This is a very poor rubric, and caused considerable difficulty for our assessors. If there are to be future projects that involve using a critical thinking rubric, it should be created from whole cloth.

  The rubric should have an explicit 5th stop on the continuum, rather than appearing to be a 4-point scale but encouraging assessors to use 0 as a 5th point for work that does not meet the benchmark.

  As defined by the rubric, the points on the scale for the traits assessed do not represent a continuum -- a project which seems more advanced than the benchmark does not necessarily satisfy one of the two milestone levels or the capstone level. Rather than representing a continuum from benchmark through capstone, the way the points on the scale are defined, they represent merely four different states of being, e.g., milestone 2 does not represent a midpoint between benchmark 1 and milestone 3 -- it is just different than either (arguably benchmark 1 may represent less accomplished skill in using evidence, and milestone 2 a greater skill in using evidence, but not necessarily movement along a continuum; milestone 2 is merely one manifestation of the way evidence might be better used drawn from a nearly infinite population of evidence more skillfully employed. In the end, few if any of the projects assessed aligned with any of the points on any of the scales. In the end, I suspect that assessors reverted to a subjective poor-fair-good-excellent scale as applied to whichever trait was being measured.

These comments demonstrate some of the problems with this particular rubric. It characterized critical thinking as a product that is documented in the project rather than a process that occurs in conjunction to the project, and which may not be explicitly documented within the project. It was for these reasons that the CLA Associate Dean suggested the use of the Inquiry and Analysis VALUE Rubric as a substitute.

6. Please explain how you created the population of projects collected and samples read.

College Summary:

In general, the programs limited their selection of projects to recent projects completed in the year prior. This happened for two main reasons. The analysis of the senior project had not been identified earlier as a possible assessment focus for program review. And, there was limited access to senior projects as a result of differences in individual department policies regarding requirements to place completed projects in Kennedy Library. Although this led to a smaller pool of potential projects for selection and scoring, departments did tend to employ some type of random selection of projects from within their sampling pools.

It should be noted that in only one case was the size of the original pool reported; Communication Studies indicated that they had collected 69 senior projects between Fall 2009 and Fall 2010. They further winnowed this down to 53 projects that were either more rhetorical/critical in nature or used a social science methodology, and then selected 12 of those, or 17%, for scoring. Departments scored between 6 projects (TH) and 16 projects (PSY). The number of projects scored was somewhat related to the size of the program.

All programs used multiple readers on the projects. Likewise, a kind of norming session took place within all programs. In general, departments were satisfied with the scoring procedure and felt that there was a reasonable level of agreement on the scores given to the projects.

Individual program reports are as follows:

- **Communication Studies -** The department set a one-year time frame (Fall 2009 through Fall 2010), during which 69 projects had been completed.

  Given the nature of the writing and critical thinking rubrics, "performance" or "service" projects for which the project document was merely a short report were eliminated from the pool, leaving a population of 53 projects for which the documents was the project (rhetorical/critical) or was an integral component of the project (social scientific).

  Given the number of faculty available to read the projects, the department arbitrarily set a sample size of 12 projects, each of which would be assigned to two faculty for assessment -- 8 raters each assessing 3 projects.

  A random number generator was used to select the 12 projects. The random generator overloaded the sample with 4 projects from a single project advisor, so 2 of those projects were replaced by the next 2 on the list not connected with that advisor.

  Information identifying the author was removed from the manuscripts, and then raters were each assigned three projects, with the coordinator making sure that no rater was assigned a project s/he had advised.

  Preliminary data analysis discovered 29 rater pairs (22%) were off my more than two rating points, two-thirds of which involved a single rater who had assigned a rating of 4 every trait on both rubrics to every project. The results form that rater were eliminated, and the three projects involved were reassigned to a substitute rater. The second attempt at data analysis indicated only 10 instances of raters off by more than two rating points (7.5%). The department determined that to be an acceptable level of rater reliability.

- **Child Development -** The faculty were asked to forward all senior projects they had readily available from the past year or two. From this pool, a sample of 12 projects was chosen using a table of random numbers. Three of these projects were the work of two-student teams. Each project sampled was randomly assigned to two faculty readers. Thus, data were provided on 24 project assessments.

- **Psychology -** The faculty were asked to forward all senior projects they had readily available from the past year or two. From this pool, a sample of 16 projects was chosen using a table of random numbers. Two of these projects were the work of two-student teams; one project was the work of a four-student group. Each project sampled was randomly assigned to two faculty readers. Thus, data were provided on 32 project assessments.

- **Philosophy -** Scores were produced in spring 2011. The ten-student sample was constructed by the department ASC working under the following method: projects from each spring from 2006 through 2010 were put in alphabetical order and then the first two from each spring were chosen. Scores were determined by a three-professor committee. The committee read and graded the projects together and arrived at each score by consensus.

- **Theatre Arts -** The samples used were gleaned from the TH 455 course related to the creation of a senior project research/career paper. Two faculty members independently engaged in reading the individual student projects: Prof. Josh Machamer, the instructor for the TH 455 course in which students write and complete the Senior Project research paper, and Dr. Virginia Anderson. Six (6) projects total were used.

7. Please provide your preliminary interpretation of these results.

College Summary:

Table 1 shows the mean college results as a function of major and rubric type. Three principal results were noted from the various analyses of the data. First, there were no significant differences across majors for either critical thinking or writing as confirmed with a non-parametric Kruskal-Wallis test. Although there was a slight trend for COMS scores to be lower than the others, this could be a result of a more stringent use of the rubric than actual differences in the writing and critical thinking scores of COMS students as compared with students in the other majors.

Table 1. Mean Scores on Writing and Critical Thinking by Major

	Major				
Rubric	COMS	CD	PHIL	PSY	TH
Critical Thinking	2.30	2.95	2.84	2.88	2.73
Writing	2.37	2.93	2.87	2.86	3.23

Second, although there was no overall difference between the critical thinking and writing mean scores, there was a significant correlation between the two scores, $r(54) = .78$, $p < .001$; students who scored high on writing also scored high on critical thinking. This was a very robust effect that recognizes the interplay between critical thinking and effective writing in the senior project.

Finally, critical thinking scores as assessed by the Inquiry and Analysis VALUE Rubric used by the Psychology and Child Development majors resulted in significantly higher scores ($M = 2.91$) as compared to those majors that used the Critical Thinking VALUE Rubric ($M = 2.58$, $t(54) = -1.99$). This was not a result of more lenient scoring by these majors; the same analysis for the writing rubric scores showed no significant difference between the two groups (as defined by the critical thinking rubrics used). This result suggests that there was a better fit between the type of critical thinking demonstrated in the CD and PSY projects and the rubric selected to measure that. The Inquiry and Analysis VALUE Rubric emphasizes "Inquiry [as] a systematic process of exploring issues, objects or works through the collection and analysis of evidence that results in informed conclusions or judgments." and "Analysis [as] the process of breaking complex topics or issues into parts to gain a better understanding of them." In contrast, the Critical Thinking VALUE Rubric emphasizes "Critical thinking [as] a habit of mind characterized by the comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating an opinion or conclusion." The requirement to demonstrate the "comprehensive exploration" seemed to create a particular obstacle, especially when it came to the trait of Evidence (see below).

Writing Traits - Within majors, two further observations can be made with regard to writing (see Table 2): 1) senior-level students are attaining at least an average level of writing skill attainment (2 or greater) across all traits, and 2) the trait results can be used to help establish a baseline for future attainment. The within-major results are especially useful for looking at the pattern of skill development across the individual traits. Although that pattern differs among the majors reviewed, some traits do seem to be more developed than others. Across the majors, Purpose was consistently strong, with scores ranging from a low of 2.54 (COMS) to a high of 3.50 (TH). In contrast, Synthesis was weaker, with scores ranging from 2.46 (COMS) to 3.33 (TH). Interestingly, both COMS and TH found that Mechanics was among the weakest traits for their students, whereas PHIL and CD found that Mechanics was the strongest. These patterns of attainment within programs can be used to help identify instructional needs and provide guidance as to where in the curriculum further instruction might occur.

Table 2. Mean Scores on Writing by Rubric Trait and Major

	Major				
Writing Rubric Trait	COMS	CD	PHIL	PSY	TH
Purpose	2.54	3.04	2.90	2.88	3.50
Synthesis	2.46	2.71	2.70	2.78	3.33
Support	2.42	3.00	2.60	2.78	3.67
Audience	2.63	3.00	2.80	3.03	---
Style	2.25	2.79	3.10	2.88	2.83
Mechanics	2.25	3.04	3.10	2.81	2.83

Critical Thinking Traits – Because two different rubrics were used to assess critical thinking, this discussion separates the trait results as a function of the different rubrics used. Tables 3 and 4 show the mean trait scores as a function of major.

a. **Critical Thinking VALUE Rubric:** The Critical Thinking VALUE Rubric was used by Communication Studies, Philosophy, and Theatre Arts. Their mean scores were 2.30, 2.84, and 2.73 respectively, though these differences were not significant and may reflect differences in how the rubrics were understood and used. In examining the different traits, Explanation of Issues was found to be among the strongest, whereas Evidence (selecting and using information to investigate a point of view or conclusion) was somewhat weaker across the board. Although, there were not consistent patterns of strengths and weakness across the programs, students in general scored at the milestone level, suggesting a "moderate" to "good" level of skill attainment.

Table 3. Mean Trait Scores on the Critical Thinking VALUE Rubric

	Major		
Critical Thinking Rubric Trait	COMS	PHIL	TH
Explanation of Issues	2.60	2.80	3.00
Evidence	2.29	2.80	2.50
Influence of Context & Assumptions	2.13	3.20	2.67
Student's Position	2.15	2.80	2.67
Conclusions & Related Outcomes	2.31	2.60	2.83

a. **Inquiry and Analysis VALUE Rubric:** The Inquiry and Analysis VALUE Rubric was used by the Psychology and Child Development Department for their two majors: Psychology and Child Development. Across both programs, the trait of Topic Selection had the highest score, followed closely by the presentation of Existing Knowledge. Lower scoring items across both programs

were in the traits of Analysis and Limitations and Implications. These results identify areas of strength and weakness in students' critical-thinking-related skill development that the department may wish to address in the curriculum and for future program review purposes. It should be noted that the overall scores were good, ranging from a low of 2.60 to a high of 3.17. Students were in the mid to high "milestone" level on all traits.

Table 4. Mean Trait Scores on the Inquiry and Analysis VALUE Rubric

	Major	
Inquiry & Analysis Rubric Trait	CD	PSY
Topic Selection	3.17	3.03
Existing Knowledge, Research &/or Views	3.04	3.00
Design Process	3.05	2.81
Analysis	2.73	2.71
Conclusions	2.95	2.71
Limitations & Implications	2.71	2.60

Individual program reports are as follows:

- **Communication Studies -** Mean ratings on the writing rubric for individual projects ranged from a low of 1.33 to a high of 3.67, with a sample mean of 2.36.

  Individual means fell into 4 clusters of unequal size. Using the language of the rubric, those clusters seem to represent superior attainment (1), good attainment (5), average attainment (3), and minimal attainment (3).

  Sample means for individual traits fell predominately in the average to good attainment range (Audience = 2.63, Purpose = 2.54, Synthesis = 2.46, and Support = 2.42). The remaining two traits fell into the minimal attainment range (Mechanics = 2.25 and Style = 2.25).

  Mean ratings on the critical thinking rubric for individual projects ranged from a low of 1.50 to a high of 3.50, with a sample mean of 2.29.

  Individual means fell into 4 clusters of unequal size. Using the language of the rubric, those clusters seem to represent capstone level (1), milestone level 2 (4), milestone level 1 (5), and benchmark level (2).

  Sample means for individual traits were distributed through the milestone 1 and 2 range: Explanation of Issues = 2.6, Conclusions and Related Outcomes = 2.31, Evidence = 2.29, Student's Position = 2.15, and Influence of Context and Assumptions = 2.13. It should be noted that the two lowest rated traits involved aspects of the rubric that faculty found most problematic (see earlier response regarding the rubric).

  The sample mean for the writing rubric (2.36) was higher than the mean for the critical thinking rubric (2.29), suggesting that, on the whole, students' writing skills are at a higher level of development than are their critical thinking skills. Additionally, two-thirds of the projects in the sample had higher writing ratings than critical thinking ratings. The third for which the reverse was true cluster at the bottom of the scale, with three of the four lowest rated projects having higher critical thinking means. For the top two-thirds of the projects, the writing mean (2.68) was

higher than the critical thinking mean (2.54), while for the lower third, the reverse was true (writing = 1.71 and critical thinking = 1.81).

As per the note above, the overall lower performance on the critical thinking scales could well be related to problems with that rubric.

Overall, the data are satisfactory. If one uses the results of this assessment project as a measure of student attainment, they suggest that a very few students are doing extremely well, the majority of the students fall somewhere in average to good range, and a very few students fall into the poor range. In other words, we have a small number of A students, the bulk of our students spread through the B and C ranges, and a few borderline students for whom graduation will be a challenge. This is consistent with other measures of student performance, including graduating grade point averages.

- **Child Development -** Both the critical thinking and writing rubrics involved six traits each on a scale with a maximum value of 4. The critical-thinking rubric's minimum scale value was 1, whereas this value was zero for the writing rubric. Initial concern that this would undermine the direct comparability of the two scales was dispelled in that no senior project ever received a trait rating of zero. In practice, therefore, both rubrics used a 1-to-4 scale. On nine occasions faculty readers found rating a particular critical-thinking trait not applicable to a given project, and these were coded as missing.

  An overall, mean rubric score, once for critical thinking and again for writing, was calculated for each of the 24 project assessments. As an initial check of the internal consistency of the rubric items, Cronbach's alpha analyses was done separately for the two rubrics. For the critical-thinking and writing rubrics, the alphas were .85 and .91, respectively. Furthermore, in neither case would dropping a scale item have resulted in a substantial improvement to alpha. Clearly, these rubrics demonstrated very good internal consistency.

  Six mean trait scores and the mean overall rubric score are reported below for each rubric as well as the percent of trait ratings of 2 or greater and 3 or greater. Because each of the 16 projects was assessed by two faculty readers, inter-rater reliability was assessed for each of the six traits and the mean overall score in both rubrics. Inter-rater reliability is reported as the Pearson correlation of the (usually 12) reader-1, reader-2 data points.

  For the critical-thinking rubric, the results were…

Trait	Mean	% ≥ 2	% ≥ 3	Correlation	p-value
Topic selection	3.17	96	92	r(10) =-.05	p = .89
Existing knowledge	3.04	100	79	r(10) = .60	p = .04
Design process	3.05	96	77	r(8) = .01	p = .97
Analysis	2.73	100	68	r(8) = .36	p = .31
Conclusions	2.95	96	68	r(9) = .37	p = .26
Limitations/Implications	2.71	91	62	r(8) = .78	p < .01
OVERALL	2.93	92	54	r(10) = .41	p = .19

For the writing rubric, the results were…

Trait	Mean	% ≥ 2	% ≥ 3	Correlation	p-value
Purpose	3.04	100	75	r(10) = .61	p = .03
Synthesis	2.71	92	63	r(10) = .32	p = .32
Support	3.00	100	71	r(10) = .58	p = .05
Audience	3.00	96	79	r(10) = .47	p = .13
Style	2.79	96	63	r(10) = .61	p = .04
Mechanics	3.04	92	79	r(10) = .56	p = .06
OVERALL	2.93	92	54	r(10) = .72	p < .01

As a final analysis, mean critical-thinking rubric scores were strongly correlated with the mean writing rubric scores, $r(22) = .83$, $p < .01$. Not surprisingly, better writing was associated with better critical thinking in the senior projects.

Nearly all of our students demonstrated at least basic competency in their critical-thinking and writing skills (i.e., trait and mean rubric scores of 2 or more). Depending on the individual trait, from 62% to 79% of our students demonstrated "high milestone" or "capstone" critical-thinking abilities and "good" to "superior" attainment of writing skills (i.e., trait scores of 3 or 4). Only 54% of the mean rubric scores reached these levels. However, with overall mean rubric scores just under 3 on both rubrics, the above results indicate that our senior project students are in general close to a "high milestone" in their inquiry and analysis skills and a "good attainment" of writing skills. Taking the liberty of a comparison with the common GPA scale, this suggests that overall critical-thinking and writing skills in our senior projects are between a B and a B-minus.

- **Psychology -** Both the critical thinking and writing rubrics involved six traits each on a scale with a maximum value of 4. The critical-thinking rubric's minimum scale value was 1, whereas this value was zero for the writing rubric. Initial concern that this would undermine the direct comparability of the two scales was dispelled in that no senior project ever received a trait rating of zero. In practice, therefore, both rubrics used a 1-to-4 scale. On five occasions faculty readers found rating a particular critical-thinking trait not applicable to a given project, and these were coded as missing. An overall, mean rubric score, once for critical thinking and again for writing, was calculated for each of the 32 project assessments.

  As an initial check of the internal consistency of the rubric items, Cronbach's alpha analyses was done separately for the two rubrics. For the critical-thinking and writing rubrics, the alphas were .80 and .93, respectively. Furthermore, in neither case would dropping a scale item have resulted in an improved alpha. Clearly, these rubrics demonstrated very good internal consistency.

  Six mean trait scores and the mean overall rubric score are reported below for each rubric as well as the percent of trait ratings of 2 or greater and 3 or greater. Because each of the 16 projects was assessed by two faculty readers, inter-rater reliability was assessed for each of the six traits and the mean overall score in both rubrics. Inter-rater reliability is reported as the Pearson correlation of the (usually 16) reader-1, reader-2 data points.

For the critical-thinking rubric, the results were…

Trait	Mean	% ≥ 2	% ≥ 3	Correlation	*p*-value
Topic selection	3.03	91	84	r(14) = .37	p = .16
Existing knowledge	3.00	100	78	r(14) = .49	p = .06
Design process	2.81	100	69	r(14) = .34	p = .20
Analysis	2.71	97	61	r(13) = .53	p = .04
Conclusions	2.71	97	61	r(13) = .65	p < .01
Limitations/Implications	2.66	90	55	r(12) = .52	p = .06
OVERALL	2.82	94	44	r(14) = .78	p < .01

For the writing rubric, the results were…

Trait	Mean	% ≥ 2	% ≥ 3	Correlation	p-value
Purpose	2.88	94	69	r(14) = .35	p = .18
Synthesis	2.78	90	66	r(14) = .67	p < .01
Support	2.78	94	56	r(14) = .46	p = .07
Audience	3.03	100	72	r(14) = .21	p = .43
Style	2.88	100	69	r(14) = .37	p = .16
Mechanics	2.81	94	59	r(14) = .49	p = .05
OVERALL	2.86	90	47	r(14) = .49	p = .05

As a final analysis, mean critical-thinking rubric scores were strongly correlated with the mean writing rubric scores, r(30) = .72, p < .01. Not surprisingly, better writing was associated with better critical thinking in the senior projects.

Nearly all of our students demonstrated at least basic competency in their critical-thinking and writing skills (i.e., trait and mean rubric scores of 2 or more). Depending on the individual trait, from 55% to 84% of our students demonstrated "high milestone" or "capstone" critical-thinking abilities and "good" to "superior" attainment of writing skills (i.e., trait scores of 3 or 4). Just under half of the mean rubric scores reached these levels. However, with overall mean rubric scores nearly 3 on both rubrics, the above results indicate that our senior project students are in general close to a "high milestone" in their inquiry and analysis skills and a "good attainment" of writing skills. Taking the liberty of a comparison with the common GPA scale, this suggests that overall critical-thinking and writing skills in our senior projects are between a B and a B-minus.

Philosophy – The two tables below show the results for writing and critical thinking respectively. The letters denote individual students.

For the writing rubric, the results were…

Criterion	A	B	C	D	E	F	G	H	I	J	Mean
Purpose	4	3	3	4	2	2	4	2	3	2	2.8
Synthesis	3	3	3	4	2	1	3	3	3	2	2.7
Support	3	3	3	3	2	2	3	3	2	2	2.5
Audience	4	3	3	4	2	1	4	2	3	2	2.8
Style	4	3	3	4	3	2	3	4	3	2	3.1
Mechanics	4	3	2	3	3	3	4	4	3	2	3.1

For the critical-thinking rubric, the results were…

Criterion	A	B	C	D	E	F	G	H	I	J	Mean
Explanation of Issues	4	3	2	4	2	2	4	2	3	2	2.8
Evidence	4	3	3	3	2	2	4	3	2	2	2.8
Influence of Context/Assumption	4	4	4	4	3	2	4	2	2	3	3.2
Student's Position	4	3	3	4	3	1	3	3	2	2	2.8
Conclusions and Outcomes	4	4	2	3	2	1	4	2	2	2	2.6

- **Theatre Arts -** The results address the continued need to provide students with enhanced tools for writing and research. While the spine of the project was found to be very clear, the approach by students in terms of detailing information lacked.

For the critical thinking rubric, the results were…

Student	Rubric	Evaluator Initials	Trait1	Trait2	Trait3	Trait4	Trait5	Mean
1	CT	JM/VA	3	2	3	3	2	2.60
2	CT	JM/VA	4	3	2	3	4	3.20
3	CT	JM/VA	2	2	2	2	2	2.00
4	CT	JM/VA	2	2	2	2	2	2.00
5	CT	JM/VA	3	3	4	3	3	3.20
6	CT	JM/VA	4	3	3	3	4	3.40
Mean			**3.00**	**2.50**	**2.67**	**2.67**	**2.83**	**2.73**

For the writing rubric, the results were…

Student	Rubric	Evaluator Initials	Trait1	Trait2	Trait3	Trait4	Trait5	Mean
1	WR	JM/VA	4	4	4	3	3	3.60
2	WR	JM/VA	4	3	4	4	4	3.80
3	WR	JM/VA	2	2	3	1	1	1.80
4	WR	JM/VA	3	3	3	3	3	3.00
5	WR	JM/VA	4	4	4	3	3	3.60
6	WR	JM/VA	4	4	4	3	3	3.60
Mean			**3.50**	**3.33**	**3.67**	**2.83**	**2.83**	**3.23**

8. Please provide your preliminary recommendations for the improvement of senior project policies/procedures at all levels.

College Summary:

The preliminary recommendations were generally absent from the initial reports. However, some of the program review reports provided recommendations based on this exercise. For example, Communication Studies wrote:

> Taken as valid measures of student attainment with respect to critical thinking and written communication learning objectives, SP2 data have implications regarding the

> department curriculum. The department's PLO curriculum map indicates that, beyond the senior project requirement, five courses set critical thinking mastery and five courses set mastery of written communication skills as course objectives (two of the courses have mastery of both skill sets as course goals). Given the structure of the degree program curriculum, students should have completed at a minimum three of those courses prior to enrolling for the senior project. On the other hand, since course objectives reflect aspirations as much as expectations, evidence of skill set mastery should be a primary distinction between A-level and B-level student performance. From that viewpoint, the disappointing feature of the SP2 data is not the composite means, but the fact there were not more students with composite means above 3.00 on one or both scales.
>
> [T]he department needs to resolve the issue of senior project assessment. The SP2 effort demonstrated that senior projects *can* be used as a source of assessment data, but the department needs to decide whether or not to move in that direction. Something else the SP2 effort demonstrated was that senior project assessment is a burden to the faculty, particularly a small faculty. SP2 investigated only two dimensions of the university learning objectives. If the senior project is thought of as a capstone experience in a sense consistent with SP1, evidence of mastery in terms of each and every university and program objective should be evident in the body of projects. That means more rubrics, more assessments per project in a given sample, and more work for already overburdened faculty members. In a sense, new assessment tasks – as seems to be the case with most of the concerns expressed and improvements suggested in this document – comes back to reclaiming (and expanding) the department's base of tenured and tenure tack faculty.

In contrast, though Philosophy does envision the senior project as a significant piece of scholarship, much like a Master's thesis, it did not find this exercise particularly useful:

> Of course, application of the writing and critical thinking rubrics to any SP would, at best, provide an inadequate basis for judging the real merit of any SP. It would, at best, constitute an assessment of form, not substance. Accordingly, such an assessment should have little to do with actual grades assigned let alone the character of the SP experience for the students and teachers involved.

As both programs suggest, the key recommendation is finding the balance between the *assessment* of student learning and providing the direct support and context for effective student learning in the senior project and throughout the curriculum. Except for those faculty who actively engage in the assessment of student learning as their scholarship, assessment for most faculty will be a means, not an end in itself, and as such need to be appropriately prioritized within the larger scheme of both faculty and student work.

Individual program reports (from the original assessment instrument) are as follows:

- **<u>Communication Studies</u> -** None. The department is satisfied with the senior project and the way it has been integrated into our curriculum. Any improvements would focus on department-level policies, not university policies/procedures.

  It should be noted that senior projects in this department are manifested in experiences that produce project manuscripts that were inappropriate for this assessment project, and thus not included in the sample of projects assessed. For the academic year contributing projects to this assessment, such projects accounted for nearly one-quarter of the entire population.

The department feels that the combination of rhetorical/critical (traditional research), social science projects (survey research, laboratory experiments, and field research), performance projects, and public service projects, gives our students the opportunity to experience "learn by doing" in a variety of ways.

- **Child Development & Psychology -** Recommendations for improvements to senior project will stem from a faculty discussion of these findings this Fall.

- **Theatre Arts -** In terms of the future, the course will look to provide more refresher/new information about database research as well as continued enhancement of writing formats/research paper construction.

Conclusions and Recommendations:

Overall, the direct assessment of critical thinking and writing in the senior project proved to be a valuable and informative experience for the majors involved and for the college more generally. Departments were engaged with the projects and understood that senior projects can be used to assess at least some program and university learning outcomes. The rubrics were usable, though, in the case of the Critical Thinking VALUE Rubric, not entirely useful. Although department faculty did appreciate what they could learn from the results, they did find the effort to be time consuming. However, the strong correlation between writing and critical thinking within senior project may mean that future assessments of these two learning objectives could concentrate on one objective or the other. Because of the time and effort involved in doing a project of this sort, reducing the scoring to just one rubric that captures multiple objectives may make a future project such as this more manageable.

Even though university-wide (or even college-wide) results were not realistically attainable from this project (due to the likelihood that departments differed on their use of the rubrics and the methods they developed around that use – e.g., in sampling, in norming), a university-wide assessment effort was nonetheless helpful. It provided some much-needed resources that were used to develop and test the rubrics. This was followed by opportunities for training on those rubrics and guidance on how to think about the methods and results (e.g., with the surveys for reporting information). Importantly, substantive discussions on assessment took place on campus in ways that they had not taken place prior.

The following recommendations are offered:

- Departments that underwent this exercise should revisit their results and be encouraged to develop at least one specific goal derived from the data. This might be as simple as verifying the patterns of results with a second sample, or better yet, defining an improvement goal, a possible intervention to reach that goal (e.g., using the writing rubric in a few courses in the major, providing more opportunities for writing in the major), and a time frame for the attainment of that goal.

- These departments should also take this as an opportunity to revisit the senior project and consider such issues as what and how much should be communicated to students about the assessment of senior project (e.g., should students be given copies of the rubric and, if so, when?), what learning outcomes are expected to be demonstrated in senior project and to what level of attainment, and what is the relationship between students' grades on senior project and their rubric scores? What relationship does the department expect? These departments might also want to consider how the rest of the major curriculum supports the development of the knowledge base

and skills needed to create a successful senior project and whether any of that needs to be reconsidered.

- The college and/or the university should provide more support for helping departments design and analyze assessment projects. The majors connected with this project actually did a very good job of defining a sampling pool and selecting from among the elements in that pool. Some of that came from the departments themselves, but some came from various university-developed documents and training workshops (especially those organized by CTL) set up to guide the process. At the same time, the reports of the results suggest that departments could have used greater support in the analysis of their data and in making recommendations from their results.

- Specific efforts to publicize the results of this assessment effort and others related to it should take place. It is important that faculty see their assessment efforts as leading to something specific and worthwhile. Reports that aggregate results across the college and university can serve to highlight what has been achieved and provide benchmarks for future achievements.

State of California
MEMORANDUM

To: Erling Smith, Vice Provost for Programs and Planning

From: Dane Jones, Associate Dean, College of Science and Mathematics

CC: Philip Bailey, Dean Wendt

Date: 12/8/2011

Re: Summary of Senior Project Assessments in CSM

Assessment of the Senior Project as a Capstone

All undergraduate degree programs in he College of Science and Mathematics (CSM) completed the Assessment of the Senior Project as a Capstone survey. The results showed CSM was in the initial and emerging stages of assessing their senior projects as a capstone. Some departments were unclear on the exact meaning of relevant terms, such as “evidence” and “outcomes”. Assessment has developed its own terminology and departments, for the most part, are still learning the details of this terminology. Most, but not all, of the departments felt the senior project was an appropriate capstone. Several departments found the rubric somewhat difficult to apply since capstone outcomes were developed independently of the ULOs and other university-wide learning outcomes. Having successful examples showing the application of the rubric to some specific department(s) would have been very helpful.

Overall, the departments in CSM felt this was a useful exercise, primarily because it showed how little the departments had done in the past to assess their senior projects. It also encouraged departments to begin a dialog on the appropriateness of the senior project as a capstone.

Assessing the Senior Project as an Artifact of Student Learning

Four programs in the CSM did the Assessing the Senior Project as an Artifact of Student Learning as part of their program review this past year: Biological Sciences (BIO), Chemistry and Biochemistry (CHEM), Kinesiology (KINE) and Liberal Studies (LS).

The enrollments during the past academic year in the senior project courses for these four departments are shown below.

2010-2011 Enrollments in Senior Project Courses					
Course	**Su 2010**	**F 2010**	**W2011**	**SP 2011**	**total**
KINE 461	8	27	41	27	103
KINE 462	0	10	8	19	37
LS 461	0	27	25	15	67
BIO 461	17	24	35	29	105
BIO 462	3	11	12	12	38
CHEM 461	3	7	11	12	33

The course evaluated was the 461 course in each department. For BIO, KINE and LS, the 461 course is either a comprehensive synthesis of professional literature integrating content from relevant courses in the department (KINE and LS) or completion of a research proposal and literature review (BIO). These departments have chosen this style of senior project primarily both to allow a relatively small number of faculty to deal with a large number of students and to insure the students complete the course within one quarter. For CHEM, Chem 461 is the senior project report based on one or more quarters of experimental research in the laboratory. In this case each student typically is working with one faculty member on the project. The project may involve a team but students typically are required to write their own reports.

Rubrics Used

BIO: BIO used the Critical Thinking Value Rubric, but since the experiment in the proposal is not completed as part of the course, the *Conclusions* section of the rubric is not applicable. They instead applied this rubric category to the experimental plan (i.e. "*Experimental plan* is logical and reflects student's informed evaluation…"). They also used the University Expository Writing Rubric, but found it difficult to apply the *Support* section of the rubric as written. They chose to use this section to evaluate the *quality* of the sources used in the proposal. Stylistic complexity is generally not valued in scientific proposal writing. Therefore they made an appropriate substitution to the *Style* section of the rubric to emphasize the importance of concise writing. (i.e. "Generally writes with concise sentence structure and language…"). Three faculty members read a total of 20 projects, with two faculty members reading each project.

CHEM: CHEM used the University Expository Writing Rubric but felt the rubric was not ideal for this style of writing because a student's report could convey scientific information properly, clearly and accurately without sophisticated style. The CHEM faculty felt the Critical Thinking Value Rubric could not be used for their project and developed their own. In addition, they felt that someone other than a student's research advisor could not accurately assess a student's level of scientific critical thinking, so the evaluations for critical thinking contain only one set of values, coming from the students' advisors. 17 projects were evaluated for writing and 31 for critical thinking.

KINE: KINE used the two rubrics supplied. They did not use the "methods" or "results" sections of the project in doing the analysis. Four projects were evaluated.

LS: LS used the two rubrics supplied. Four faculty were involved in reading the 11 reports and each report was read by at least two faculty members.

Summary Results

A table summarizing the results of the Assessing the Senior Project as an Artifact of Student Learning project is given below. An average for the college is given for the writing rubric (WR), but no average is given for the critical thinking rubric (CT) since each department treated this part of the assessment differently.

Department	Rubric	Trait 1	Trait 2	Trait 3	Trait 4	Trait 5
Biological Sciences	WR	2.19	2.03	2.36	1.97	2.53
	CT	2.33	1.81	1.72	1.72	1.97
Liberal Studies	WR	3.14	2.89	2.75	2.80	3.07
	CT	2.86	2.80	2.68	2.64	2.66
Chemistry and Biochemistry	WR	2.06	2.29	2.59	2.65	2.71
	CT-A	2.68	2.72	2.60	2.48	2.43
Kinesiology	WR	2.38	1.50	2.38	1.63	2.00
	CT	2.50	1.88	2.13	1.88	2.25
College Average	WR	2.44	2.18	2.52	2.26	2.58

General Comments

Overall, the departments felt this was a worthwhile endeavor. All agreed their senior projects were in need of better assessment. Below are given some of the key points raised by this exercise.

- For the more hard-science departments, the rubrics as written were problematic.
- It was difficult, in most cases, to collect projects and make them ready for distribution. None of the departments really felt they had done a statistically significant sampling of the projects.
- Guidelines for the assessment changed throughout the process. For example, most departments removed all identifying information at the outset, but later were told to use students' EMPL ID numbers.
- It was difficult to engage sufficient numbers of faculty in the project.
- Most departments found it problematic to calibrate reviewers. One department felt only the advisor could evaluate the project.
- The senior project is often in poor alignment with the ULOs
- It may prove more useful to allow academic units to identify their own "capstone" experiences. The research-based senior projects benefit faculty research and enhance the teacher-scholar model.
- The completion of senior projects in a timely manner has been a large problem for many departments in the past, and has necessitated the revision of the senior project itself. Other departments feel completion is the student's responsibility, and is one important facet of the project. One department showed remarkable increases in graduation rates when the program switched to a one-quarter proposal writing course for the senior project.
- Having several faculty members evaluate each senior project is very time consuming, and if required, could delay a student's graduation.
- Some parts of the senior projects were found to be better than expected, while others (often involving depth of bibliography) were weaker than expected.
- Since some of the projects often involved several rewrites, aided by the research advisor or faculty member teaching the course, the final document in these cases was not a true representation of the student's abilities, but strongly reflected the advisor's work and tastes.
- For those senior projects involving a laboratory component, the written report was but one of several major elements of the project. Developing a process allowing for evaluation of these projects by multiple reviewers will require significant future work.
- None of the departments regularly submitted senior projects to the Digital Commons. For some departments, the senior project is more of a term paper and really doesn't belong in the Digital Commons. For departments where the senior project report is more akin to a publication-style document, there were concerns a mediocre project could reflect badly on the advisor. Some projects also contain proprietary information and the report would have to be rewritten so it could be archived in a public repository.
- All departments were painfully aware of the conflicts between faculty engaging in research (as part of the teacher-scholar model and to meet requirements for retention and promotion), lack of funding and space for faculty research, time demands on faculty due to heavy teaching loads, and the desire to provide students with unique, individualized capstone experiences.
- This assessment has started a useful and, hopefully, productive dialog in all departments leading to a better understanding of the goals and objectives of the senior project.