Learning Outcomes Data
for the
Senate Committee on
Instructional Program Priorities

Program: Computer Engineering Program (CPE)
Department: Electrical and Electronic Engineering
Number of students enrolled in the program in Fall 2011: 184
Faculty member completing template: Dr. Suresh Vadhva
(Date: 1/3/2012)
1. Please describe your program’s learning-outcomes trajectory since 2006-07: Has there been a transformation of organizational culture regarding the establishment of learning outcomes and the capacity to assess progress toward their achievement? If so, during which academic year would you say the transformation became noticeable? What lies ahead; what is the next likely step in developing a learning-outcomes organizational culture within the program?

The mission of the Computer Engineering Program is to offer a comprehensive course of study that balances education in both hardware and software design. Special emphases include: teaching fundamentals, balancing theory with design and technology tools, providing practical experience via projects and labs, and fostering professional growth. The program serves residents and industry in the university’s service area.

We have successfully received accreditation from the Accreditation Board for Engineering and Technology (ABET) several times and in 2009 we received full accreditation. Our transformation due to assessments has been embedded into our programs starting in 2000. We will continue our assessment process as required by ABET.

2. Please list in prioritized order (or indicate no prioritization regarding) up to four desired learning outcomes (“takeaways” concerning such elements of curriculum as perspectives, specific content knowledge, skill sets, confidence levels) for students completing the program. For each stated outcome, please provide the reason that it was designated as desired by the faculty associated with the program. [Please limit your response per outcome to 300 words or less].

Our department’s learning outcomes were developed and approved by CPE faculty in order to be consistent with the requirements set forth by ABET shown below:

a. an ability to apply knowledge of mathematics, science, and engineering or computing as appropriate to discipline
b. an ability to design and conduct experiments, as well as to analyze and interpret data, or an ability to analyze a problem and identify and define the computing requirements appropriate to solution
c. an ability to design a system, component, program 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. an understanding of the impact of engineering or computing 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 and continuing professional development
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering and computing tools necessary for engineering or computing practice.
Specifically, the CPE faculty has adopted a set of 14 student learning outcomes which define what students are expected to know and be able to do by the time they graduate. These parallel to the requirements of ABET Engineering Criterion 3 items (a) through (k) and applicable Program Criteria. This relationship is detailed parenthetically below.

All students of the CPE program at CSUS are expected to have at the time of graduation:

1. A knowledge of mathematics through differential and integral calculus, differential equations, physics and chemistry (Program Criteria)
2. A knowledge of basic engineering sciences (Program Criteria)
3. The ability to apply knowledge of mathematics, science and engineering to solve problems in CPE (Engineering Criterion 3(a))
5. Knowledge of probability, statistics and discrete structures. (Program Criteria)
6. The ability to use contemporary engineering techniques and tools for analysis and design. (Engineering Criterion 3(k))
7. The ability to work with modern instrumentation, software and hardware, design and perform experiments, and analyze and interpret the results. (Engineering Criterion 3(b), Program Criteria)
8. The ability to integrate knowledge gained from the core curriculum to solve a complex design problem. This includes the identification, specification, design and implementation of products/components and/or systems that meet desired safety, economic and performance criteria. (Engineering Criterion 3(c, e), Program Criteria)
9. The ability to function on multi-disciplinary teams and exercise leadership to accomplish project goals. (Engineering Criterion 3(d))
10. The ability to communicate effectively through written technical papers and/or project reports. (Engineering Criterion 3(g))
11. The ability to make effective oral presentations and convey technical material to an audience. (Engineering Criterion 3(g)).
12. An understanding of professional and ethical responsibility and a broad education to appreciate the impact of engineering solutions in the societal context. (Engineering Criterion 3(f,h, j))
13. Recognition of the need for and an ability to engage in “life-long” learning. (Engineering Criterion 3(i))
14. An appreciation for and knowledge of diverse cultures and demonstrated proficiency in a foreign language.

Each course in the CPE curriculum has clearly defined objectives, a set of measurable outcomes, and contributes to one or more of the program’s student learning outcomes. The relationship of specific courses in the curriculum and the 5 areas of general education requirements to each individual student learning outcome (1-14) is listed below:

### Table X. Relationship of CPE Courses to CPE Student Learning Outcomes

<table>
<thead>
<tr>
<th>Student</th>
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### Learning Outcomes

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<tr>
<th>Required Lower Division Courses:</th>
<th>Knowledge of Math</th>
<th>Knowledge of Engineering Science</th>
<th>Application of Math to solve Knowledge of CPE Core</th>
<th>Knowledge and Application of Probability &amp; Stats. &amp; And</th>
<th>Use Contemporary Tools for Analysis &amp; Design</th>
<th>Experimental Work</th>
<th>Integration to solve complex design problem</th>
<th>Teamwork</th>
<th>Written Communications</th>
<th>Oral Communications</th>
<th>Professionalism &amp; Ethics</th>
<th>Lifelong Learning</th>
<th>Diversity</th>
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<th>Knowledge of Math</th>
<th>Knowledge of Engineering Science</th>
<th>Application of Math to solve Knowledge of CPE Core</th>
<th>Knowledge and Application of Probability &amp; Stats. &amp; And</th>
<th>Use Contemporary Tools for Analysis &amp; Design</th>
<th>Experimental Work</th>
<th>Integration to solve complex design problem</th>
<th>Teamwork</th>
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<th>Additional Required Courses:</th>
<th>Knowledge of Math</th>
<th>Knowledge of Engineering Science</th>
<th>Application of Math to solve Knowledge of CPE Core</th>
<th>Knowledge and Application of Probability &amp; Stats. &amp; And</th>
<th>Use Contemporary Tools for Analysis &amp; Design</th>
<th>Experimental Work</th>
<th>Integration to solve complex design problem</th>
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<tr>
<th>Required Upper Division Courses:</th>
<th>Knowledge of Math</th>
<th>Knowledge of Engineering Science</th>
<th>Application of Math to solve Knowledge of CPE Core</th>
<th>Knowledge and Application of Probability &amp; Stats. &amp; And</th>
<th>Use Contemporary Tools for Analysis &amp; Design</th>
<th>Experimental Work</th>
<th>Integration to solve complex design problem</th>
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3. *For undergraduate programs only*, in what ways are the set of desired learning outcomes described above aligned with the University’s Baccalaureate Learning Goals? Please be as specific as possible. **[Please limit your response per outcome to 300 words or less]**

The CPE Program at CSUS aims to provide high quality education that will transform students into professional engineers who are prepared to meet the needs of society and adapt to rapidly changing technology. Thus, the learning outcomes of the CPE Program are aligned with the Baccalaureate Learning Goals of California State University, Sacramento. The CPE Program’s learning outcomes include emphasis on the achievement of critical problem-solving and communication skills.
alongside accomplished ability in the Computer Engineering discipline. Also emphasized is the need for professionalism, ethics and flexibility within society.

CPE Program Outcomes as Related to California State University, Sacramento’s Baccalaureate Learning Goals

<table>
<thead>
<tr>
<th>ECS Matrix</th>
<th>BACCALAUREATE LEARNING GOALS</th>
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<tbody>
<tr>
<td></td>
<td>Competencies in the Disciplines</td>
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<td>Learning Outcomes</td>
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According to ABET students should be taught to develop:

- a. an ability to apply knowledge of mathematics, science, and engineering or computing as appropriate to discipline
- b. an ability to design and conduct experiments, as well as to analyze and interpret data, or an ability to analyze a problem and identify and define the computing requirements appropriate to solution
- c. an ability to design a system, component, program 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. an understanding of the impact of engineering or computing 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 and continuing professional development
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering and computing tools necessary for engineering or computing practice.

4. For each desired outcome indicated in item 2 above, please:
   a) Describe the method(s) by which its ongoing pursuit is monitored and measured.
   b) Include a description of the sample of students (e.g., random sample of transfer students declaring the major; graduating seniors) from whom data were/will be collected and the frequency and schedule with which the data in question were/will be collected.
   c) Describe and append a sample (or samples) of the “instrument” (e.g., survey or test), “artifact” (e.g., writing sample and evaluative protocol, performance review sheet), or other device used to assess the status of the learning outcomes desired by the program.
   d) Explain how the program faculty analyzed and evaluated (will analyze and evaluate) the data to reach conclusions about each desired student learning outcome.

   [Please limit your response to 200 words or less per learning outcome]

   (If the requested data and/or analysis are not yet available for any of the learning outcomes, please explain why and describe the plan by which these will occur. Please limit your response to 500 words or less.)

All of the learning objectives use the same monitoring and measuring techniques, program constituencies, assessment instruments and means of evaluation. First, these learning outcomes are monitored and measured based on input from the constituencies of the program, which include:

1. students
2. alumni
3. industry employers
4. CPE faculty

Second, below is a chart with information about the type of instruments, artifacts and other devices collected from each constituency to assess the status of CPE learning outcomes:

<table>
<thead>
<tr>
<th>Constituency</th>
<th>Specific Group</th>
<th>Timelines</th>
<th>Type of Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>All students</td>
<td>Every year</td>
<td>Student Survey</td>
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<td></td>
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<td></td>
<td>Course Embedded Assessment</td>
</tr>
<tr>
<td>Alumni</td>
<td>Graduating classes 5 years</td>
<td>Every three years</td>
<td>Alumni Survey</td>
</tr>
<tr>
<td>Faculty</td>
<td>Full time and part time</td>
<td>Every three years</td>
<td>Faculty Survey</td>
</tr>
</tbody>
</table>
The following section provides more specific details about our department’s assessment methods:

**Course Level Assessment (Direct Measurement)**

Course Embedded Assessment (CEA) represents the “bricks and mortar” of our assessment program. Our experience shows that assignments and exams in individual courses provide immediate and valuable feedback to both the student and the faculty. Assignments and examinations include midterms and final which are required in all courses. In addition, projects, Computer Aided Design and term papers are required in several classes as appropriate. They allow the faculty to identify any potential problems in related courses. For instance, if the performance of several students in a given exam or assignment indicates that they do not understand a concept they should have acquired in a prerequisite course, that probably indicates a problem with the related course.

We have established a CEA process that focuses on a set of core classes required of all students in our major. Each course has detailed objectives, specific course outcomes, and indicators that are monitored to ensure successful achievement of those outcomes. The Course Coordinators for courses covered by CEA present a report to the Department faculty reflecting on student achievement on the specific course outcomes and course topics, whether prerequisites are appropriate, student reactions to the course, and suggested changes if any.

This process is useful because it enables faculty who are not directly involved in specific courses from the CEA group to get a full understanding of the courses in the CEA group and make any adjustments to their own courses. It allows new faculty and part-time faculty to acquire a thorough understanding of the curriculum and become familiar with the challenges by perusing the annual CEA reports. Also, the process ensures that faculty in related courses interact with each other on a regular basis when preparing the CEA report for a particular course. Equally important, the CEA reports provide the documentation to illustrate how the faculty uses assessment results for ongoing program improvement.

For courses that are not part of the CEA group, individual faculty members who teach the course are responsible for course-level assessment. Each course has clearly defined objectives, a set of measurable outcomes, and contributes to one or more of the program’s student learning outcomes. The faculty member teaching the course is responsible for reporting any major issues that are revealed from outcomes assessment and initiating appropriate changes to ensure that the course objectives are met successfully.
Program Level Assessment (Indirect Measurement)

Outcomes assessment at the program level is carried out by using a variety of assessment tools:

1. Student and alumni surveys reflecting on program outcomes.
2. Site visits to industry.
3. Independent assessment by Department-level Industry Representatives.
4. Feedback from College’s Industry Advisory Board.
5. Exit Interviews with graduating seniors

Since faculty is primarily responsible for assessments, we use faculty surveys to set indicators as appropriate for our program outcomes. In some instances it is more appropriate to use qualitative indicators to assess success of a particular outcome (typically feedback and action items resulting from independent assessment by the Department’s Industry Representatives).

Assessment Instruments

In order to meet ABET Engineering Criteria with respect to assessment we use the following assessment instruments in our program:

Surveys of Graduating Seniors: Graduating seniors are surveyed at the time of graduation for their perceptions about the program’s educational objectives and student learning outcomes, our relative success in achieving those outcomes, and suggestions for improvement.

Alumni Surveys: Alumni from our program are surveyed five years out (1997-2001 alumni for the 2002 academic year) to rank the importance of each of our student learning outcomes in the context of their current professional position and their level of preparation with respect to that objective or outcome.

Industry Focus Teams Visits: Faculty teams visit a company or industry that employs several graduates from our program to meet with a group of our alumni. Typically the alumni include recent graduates (1-5 years out), as well as experienced engineers and managers (6-10 years out, 11 years and over). A set of open-ended questions is distributed to the site prior to the visit to provide a foundation for the participants. The interviews are audio taped and placed on the Web for faculty to review following the visit. A written transcript is also produced and shared with all faculty members. The reports are analyzed and action items with appropriate timelines are developed for implementation.

Industry Liaison Council: The CPE program enjoys a relationship with engineers from industry representing all major areas of emphasis in the CPE program. The program meets with industry representatives biannually and the industry representatives provide the program and the faculty with independent feedback on its efforts to achieve the student learning outcomes.

Industry Advisory Board: At the College level, the IAB receives reports from each program on a biannual basis and evaluates each program’s success in implementing the strategic plan of the college. The IAB meets in executive sessions following the presentations and reports back to the Program Coordinators, Department Chairs and Deans with specific recommendations for follow up and action.
**Employer Surveys:** The College’s Career and Placement Office periodically surveys employers and provides salary information and relevant information on upcoming trends and opportunities to the programs.

**Exit Surveys:** Graduating students are surveyed.

**Survey Example:**

As part of the exit survey process, graduating seniors are asked to answer 100 questions, ranging from general background information to current employment status and from their personal level of achievement of each of the CPE program outcomes to their opinion on each SLO’s relevance. Data collected from graduating students on program outcome achievement and relevance is especially useful. Specific program objectives and learning outcomes are assessed by asking to what degree graduating students’ CPE education prepared them in specific areas. The specific survey text is presented in Appendix F.

Nine (n=9) students recently graduated from the CPE program, and the mean and standard deviation of perceived alumni preparation in ABET criteria (a) is presented below using a scale of (1) Not at all, (2), (3), (4) Moderately, (5), (6), and (7) Extremely.

| ABET Criterion 3(a) an ability to apply knowledge of mathematics, science, and engineering |
|---------------------------------|-----|----------------|
| Q045. Program Outcomes and Assessment - Skill Development - Degree that engineering education enhanced ability to: Apply knowledge of mathematics | N = 6 | Mean = 5.33 |
| Scale: (1) Not at all,(2),(3),(4) Moderately,(5),(6),(7) Extremely,Not applicable | Std Dev = 1.37 |
| Q046. Program Outcomes and Assessment - Skill Development - Degree that engineering education enhanced ability to: Apply knowledge of science | N = 7 | Mean = 5.86 |
| Scale: (1) Not at all,(2),(3),(4) Moderately,(5),(6),(7) Extremely,Not applicable | Std Dev = 0.83 |
| Q047. Program Outcomes and Assessment - Skill Development - Degree that engineering education enhanced ability to: Apply knowledge of engineering | N = 9 | Mean = 6.33 |
| Scale: (1) Not at all,(2),(3),(4) Moderately,(5),(6),(7) Extremely,Not applicable | Std Dev = 0.67 |

**Review:** Perceived degree to which CPE education enhanced students’ ability to apply the knowledge of mathematics, science and engineering is high in all areas. Alumni’s perceived ability to apply the knowledge of engineering is highest, and has the lowest standard deviation.

5. Regarding each outcome and method discussed in items 2 and 4 above, please provide examples of how findings from the learning outcomes process have been utilized to address decisions to revise or maintain elements of the curriculum (including decisions to alter the program’s desired outcomes). If such decision-making has not yet occurred, please describe the plan by which it will occur.
[Please limit your response to 200 words or less per item]

Through the years, positive responses from alumni surveys and exit interviews has reinforced that implemented changes to the CPE curriculum as a result of course level assessment have been beneficial. Alternatively, improved student performance in the core curriculum has reinforced changes made as a result of program constituent feedback through surveys and interviews. In this self-perpetuating manner, direct and indirect methods of assessment work as a system of checks and balances for the achievement of student learning outcomes. The CPE faculty puts great emphasis on ensuring that the curriculum pattern serves students in the best way possible. Bi-monthly meetings and constant discussions concerning courses and students’ needs are part of what the CPE faculty regards as necessary in order to provide the best service to the students.

The CPE Program at CSUS developed program educational objectives and from this set of objectives we developed a set of program learning outcomes. Our goal in designing the outcomes corresponding to each objective is to ensure that if every student achieves the skills and abilities specified in each of the outcomes corresponding to an objective, then the program through appropriate measurement of that outcome can satisfy the corresponding objective. The following is an outline of the process for establishing and revising all CPE program outcomes:

i. Define goals, objectives, and learning outcomes

ii. Identify performance criteria and measurement metric for each learning outcome and identify the courses that support the outcome.

iii. Identify assessment tools and provide data relevant to each learning outcome

iv. Develop plan to assess achievement of program goals and learning outcomes

v. Identify problem areas and develop strategies for improving delivery of learning outcomes

vi. Implement strategies targeted at improving specific learning outcomes and assess the effectiveness of the changes

vii. Reassess objectives and learning outcomes and continue the process.

6. Has the program systematically sought data from alumni to measure the longer-term effects of accomplishment of the program’s learning outcomes? If so, please describe the approach to this information-gathering and the ways in which the information will be applied to the program’s curriculum. If such activity has not yet occurred, please describe the plan by which it will occur.

[Please limit your response to 300 words or less]

In particular, alumni of the program represent a much broader spectrum of individuals with a wide range of experience in their lives and careers. It is very important to include their feedback in evaluating the program’s success in meeting its desired PEOs. Alumni input are sought through
standard surveys disseminated every three years. Based on the information collected, CPE faculty members analyze and evaluate the information by comparing it to the specified learning outcomes. Then, changes are made to the objectives as needed.

7. Does the program pursue learning outcomes identified by an accrediting or other professional discipline-related organization as important? Does the set of outcomes pursued by your program exceed those identified as important by your accrediting or other professional discipline-related organization?

[Please limit your response to 300 words or less]

The CPE Department meets the criterion established by ABET Engineering Criterion 3, which states 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.

The CPE faculty has adopted a set of 14 “Student Learning Outcomes” or SLOs, which define what students are expected to know and be able to do by the time they graduate. These SLOs coincide with the requirements of ABET Engineering Criterion 3, items (a) through (k) and applicable Program Criteria, and this relationship is detailed parenthetically below.

All students of the CPE program at CSUS are expected to have at the time of graduation:

1. A knowledge of mathematics through differential and integral calculus, differential equations, physics and chemistry (Program Criteria)
2. A knowledge of basic engineering sciences (Program Criteria)
3. The ability to apply knowledge of mathematics, science and engineering to solve problems in CPE (Engineering Criterion 3(a))
5. Knowledge of probability, statistics and discrete structures. *(Program Criteria)*
6. The ability to use contemporary engineering techniques and tools for analysis and design. *(Engineering Criterion 3(k))*
7. The ability to work with modern instrumentation, software and hardware, design and perform experiments, and analyze and interpret the results. *(Engineering Criterion 3(b), Program Criteria)*
8. The ability to integrate knowledge gained from the core curriculum to solve a complex design problem. This includes the identification, specification, design and implementation of products/components and/or systems that meet desired safety, economic and performance criteria. *(Engineering Criterion 3(c, e), Program Criteria)*
9. The ability to function on multi-disciplinary teams and exercise leadership to accomplish project goals. *(Engineering Criterion 3(d))*
10. The ability to communicate effectively through written technical papers and/or project reports. *(Engineering Criterion 3(g))*
11. The ability to make effective oral presentations and convey technical material to an audience. *(Engineering Criterion 3(g))*.
12. An understanding of professional and ethical responsibility and a broad education to appreciate the impact of engineering solutions in the societal context. *(Engineering Criterion 3(f, h, j))*
13. Recognition of the need for and an ability to engage in “life-long” learning. *(Engineering Criterion 3(l))*
14. An appreciation for and knowledge of diverse cultures and demonstrated proficiency in a foreign language.

8. Finally, what additional information would you like to share with the Senate Committee on Instructional Program Priorities regarding the program’s desired learning outcomes and assessment of their accomplishment?

[Please limit your response to 200 words or less]

We have successfully received ABET accreditation in 2009, 2003 and 1997. We look forward to continuing to successfully achieve ABET accreditation in the future.