UNIVERSITY of CALIFORNIA Riverside
BOURNS COLLEGE OF Engineering

Self-Study Report

Chemical Engineering

Submitted by:
Bourns College of Engineering
University of California
A342 Bourns Hall
Riverside, CA 92521
(951) 827-5190

Prepared for:
ABET, Inc.
111 Market Place, Suite 1050
Baltimore, MD 21202-4012

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A. Background Information

A.1 Degree Titles

The Bourns College of Engineering consists of four departments (Chemical and Environmental Engineering, Computer Science and Engineering, Electrical Engineering, Mechanical Engineering) and four research centers, offering the following degrees. A fifth department, Bioengineering, will become independent of Chemical and Environmental Engineering in the fall of 2006.

Degree	Title	Established/Effective Dates
BS	Bioengineering	Fall 2005
BS	Chemical Engineering: Concentration in Biochemical Engineering	Established fall 1986, first freshmen admitted fall 1990; effective as of fall 2002
BS	Chemical Engineering: Concentration in Biochemistry	Established fall 1986, first freshmen admitted fall 1990; effective through 2001-02 academic year
BS	Chemical Engineering: Concentration in Bioengineering	Effective beginning fall 2003
BS	Chemical Engineering: Concentration in Chemical Engineering	Effective beginning fall 2002
BS	Chemical Engineering: Concentration in Chemistry	Established 1986; first freshmen admitted fall 1990; effective through the 2001-02 academic year
BS	Computer Engineering	Established fall 1999
BS	Computer Science	Established fall 1992
BS	Electrical Engineering	Established fall 1986; first freshmen admitted fall 1989
BS	Environmental Engineering: Concentration in Water Pollution Control	Established fall 1986; first freshmen admitted fall 1990
BS	Information Systems	Established fall 2001
BS	Mechanical Engineering	Established fall 1990; first freshmen admitted fall 1994
MS	Chemical & Environmental Engineering	Established fall 1998
MS	Computer Science	Established fall 1999
MS	Electrical Engineering	Established fall 1999
MS	Mechanical Engineering	Established fall 2001
Ph.D.	Chemical & Environmental Engineering	Established fall 2003
Ph.D.	Computer Science	Established fall 1991
Ph.D.	Electrical Engineering	Established fall 1999
Ph.D.	Mechanical Engineering	Established fall 2001

A.2 Program Modes

The undergraduate programs in the Marlan and Rosemary Bourns College of Engineering are offered only in the traditional day-time mode.

A.3 Actions to Correct Previous Shortcomings

A summary of ABET Final Statement provided for the Chemical Engineering Program following the Fall 2000 visit appears below. Note that the previous ABET review was conducted under the "old" criteria.

FINAL STATEMENT UNIVERSITY OF CALIFORNIA, RIVERSIDE

Chemical Engineering
Program

Introduction

The chemical engineering program is a relatively new program that was first accredited in 1995. There are a total of nine and one-half full-time and four part-time chemical engineering faculty members. Many of the faculty members are at an early stage in their careers and are actively developing new research and teaching programs. Balance is achieved with senior faculty members who are more mature in their research and teaching areas.

Program Strengths

1. Faculty teaching loads are reasonable, and the faculty members interact by helping each other develop student design projects. The faculty is encouraged to continue this interaction and extend it in preparation for review under the new ABET EC2000 criteria. A number of the faculty members have industrial or government experience, which is an asset in teaching some of the design-oriented classes. The faculty members are to be complimented for the effort and hard work that it took to complete the materials in preparation for this visit.

2. The number of students in the program is small. Students perceive the smaller class sizes as a definite advantage of attending UCR. The students are well qualified, and they are well pleased with the quality of instruction that they receive. They feel that they will be well prepared to enter the chemical processing industry upon completion of their degree. The students are also excited about opportunities to participate in faculty research programs.

3. An inspection of student work indicates that there is a reasonable integration of design content throughout the curriculum. The students have access to computer laboratories equipped with the most recent advanced design and simulation software available. The students have access to an excellent technical library for the purpose of performing literature searches and obtaining journal articles that may be needed to complete their assignments.

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All students obtain an excellent laboratory experience in fundamental chemical engineering principles.

Program Weakness

1. Criterion I.C.2. Curricular Objective The chemical engineering program does not clearly demonstrate how all of its program goals are in harmony with the institutional goals and does not clearly demonstrate how all of the goals are satisfied.

   - Due process response: Information in volume II of the chemical engineering program self-study has been supplemented in the response, and steps have been taken by the faculty to "develop more quantitative mechanisms for measuring success in reaching the program goals".

   - This weakness has been resolved.

Program Concern

1. Criterion I.C.6.d. Laboratory Plan Each curriculum must have a carefully constructed and functioning laboratory plan. The chemical engineering laboratory plan is incomplete.

   - Due process response: The program submitted a newly developed, complete, and comprehensive laboratory plan.

   - This concern has been resolved.

Program Observations

1. The faculty is continually reviewing and improving the curriculum based on feedback from instructors and students. For example, this process has resulted in a recent proposal to divide the existing four-hour introductory Chemical Process Analysis course, into two three-hour courses. Such activities are encouraged and should be continued.

2. There may be a current need to expand the existing Process Control course to include more than one laboratory experiment. The purpose of the experiments would be to provide students with a wider range of practical control experiences.

In summary, there were no remaining concerns or weaknesses after the due process response. Our Curricular Objectives are now published both on our departmental web page and in the printed and on-line versions of UCR's General Catalog. A structured process for evaluating the degree to which these objectives as well as outcomes are met has been developed and implemented. Since 2000, maintenance and new acquisition of instructional equipment has been streamlined. The support and resources for purchasing and maintenance of instructional equipment are presented in Section B.7.

Regarding the two observations that were made, we have continued to review and to improve our curricula as part of the ABET assessment process and motivated by the desire to develop more attractive programs. This has resulted in dividing the 4 unit Chemical Process Analysis (CHE 110) course into two three-hour courses (CHE 110A and CHE 110B) as wells as the implementation of several new technical electives (e.g., CEE 132 Green Engineering) and in the implementation of a new Bioengineering option. In summer 2006, an Advanced Materials/Nanotechnology option will be submitted for approval. A Renewable Energy option will be proposed for environmental engineering, which will provide further opportunities to expand the technical electives offering. With respect to Observation #2, a new Process Control practical experiment was developed (temperature and level control in a CSTR) in 2003.

At the College level, the ABET reviewers identified two Institutional Concerns:

1. Each program was found to have a weakness with respect to engineering topics, specifically criterion I.C.3.d.(3)(e), which states that the public and ABET "should be able to discern the goals of a program and the logic of the selection of the engineering topics in the program." This weakness was resolved by publication on the web page. However, it remained a concern at that time pending publication of the appropriate statements in catalogs and other publications available to the public. This has been resolved.

2. Faculty advising was found to be a concern because the staff of the student affairs office was physically unable to see all of the undergraduates during the three-week registration period each quarter. The reviewers noted that the office has been creative in devising a plan whereby all students who need to see an advisor may do so each quarter. The College noted that new and revised advisement programs were being implemented. This concern has been resolved.

A.4 Contact Information

The Chair of the Department of Chemical and Environmental Engineering is Marc Deshusses. He will serve as the main point of contact for the visit. The ABET review and assessment process in the Chemical and Environmental Engineering (CEE) Department is organized as follow. There is an ABET Accreditation and Assessment Committee (hereafter ABET Committee), which is composed of the Undergraduate Studies Committee. The committee is chaired by the faculty representing the department in the College-wide ABET Committee. This was Prof. Y. Yan until December 2005. He was replaced by Prof. D. Cocker in January 2006. Drs. Deshusses and Cocker had the primary responsibility for preparation of this Self-Study Report and planning of the site visit. Contact information for these individuals is given below:

Marc A. Deshusses, Ph.D. Professor and Chair Department of Chemical and Environmental Engineering University of California, Riverside, CA 92521 Tele: (951) 827 2477 Fax: (951) 827 5696 e-mail: mdeshuss@engr.ucr.edu	David Cocker, Ph.D. Associate Professor and Chair of ABET Accreditation and Assessment Committee Department of Chemical and Environmental Engineering University of California, Riverside, CA 92521 Tele: (951) 781 5695 Fax: (951) 827 5696 e-mail: dcocker@engr.ucr.edu

B. Accreditation Summary

This section describes, in turn, our methods for advising students (B.1), our program educational objectives (B.2), our program outcomes and assessments (B.3), the program's professional component (B.4), faculty (B.5), facilities (B.6), institutional support and financial resources (B.7), and program criteria (B.8).

B.1 Students

Criterion 1 calls for the institution to evaluate student performance, advise students regarding curricular and career matters, and monitor student progress to foster success in achieving program outcomes, thereby enabling them as graduates to attain program objectives. This subsection describes the Bourns College of Engineering's steps to fulfill Criterion 1. We first provide an overview of the student population that UCR and the Bourns College of Engineering serve, and our philosophy and approach for serving them. Next, we address student advising and then describe procedures for monitoring and verifying student credits earned toward graduation. Finally, we describe the College's Professional Development Milestones program, which helps students prepare for internship and career opportunities while they are undergraduates.

B.1.1 Student Population Characteristics and Implications

The University of California, Riverside, maintains an inclusive admissions policy and emphasizes opportunity over exclusivity. Consequently, our freshman cohort typically comprises students from a very broad range of academic, cultural, and socioeconomic backgrounds. A significant fraction (~55%) of our entering freshmen are the first in their families to go to college. There is also considerable variance within each freshman cohort in the degree of academic preparation and SAT scores.

This variance in backgrounds and preparation tends to reduce success rates both within our three colleges and from the campus as a whole. Table 1 summarizes the 6-year graduation rates for the three colleges within UCR that enroll undergraduates.

Table 1. Graduation rates from UCR colleges after 6 years.

College entered	College graduated from			Graduated from UCR
	BCOE	CNAS	CHASS	
Bourns Coll. of Engineering (BCOE)	**38.0%**	2.2%	22.8%	63.0%
Natural & Agricultural Sciences (CNAS)	3.1%	**30.5%**	28.8%	62.4%
Humanities & Social Sciences (CHASS)	0.9%	2.0%	**63.4%**	66.2%

Our graduation rates are significantly lower than we would like. We have found that the bulk of the attrition among BCOE freshmen occurs in the first year or two, an observation consistent with the experience of other engineering programs across the nation. In our case, poor academic preparation in high school is the most important factor influencing academic success. While the campus does support numerous programs and courses designed to address this issue, UCR's charter does not include remedial education, so it is not likely that our college or our campus can significantly influence learning outcomes in high schools.

Therefore, we have decided to focus on improving retention by identifying and addressing other issues upon which we are likely to have control. Based on the exit surveys we give to graduating seniors (see Section B.3), we have determined that lack of engagement with the College in the early years and inadequate mentoring are two such issues. In response, we have initiated programs to increase students' engagement with the engineering curriculum and the engineering faculty, as discussed below.

As is typical for undergraduate programs in engineering, our students spend the first two years of their undergraduate work completing prerequisite coursework in mathematics, the sciences, and the humanities and social sciences. Unfortunately, instructors in these areas are unfamiliar with any of the engineering disciplines, and unable to motivate or mentor our students in their early years here. Consequently, our students fail to develop a clear sense of academic direction or a sense of professional pride, having no role models or mentors, either at home or on campus.

Figure 1 shows the patterns of persistence in the College of Engineering since inception. We lose between 40% and 50% of our students in the first two years alone. Most relevant to our plans are the trends in the last five years, which shows a clear and worrisome worsening of our persistence figures.

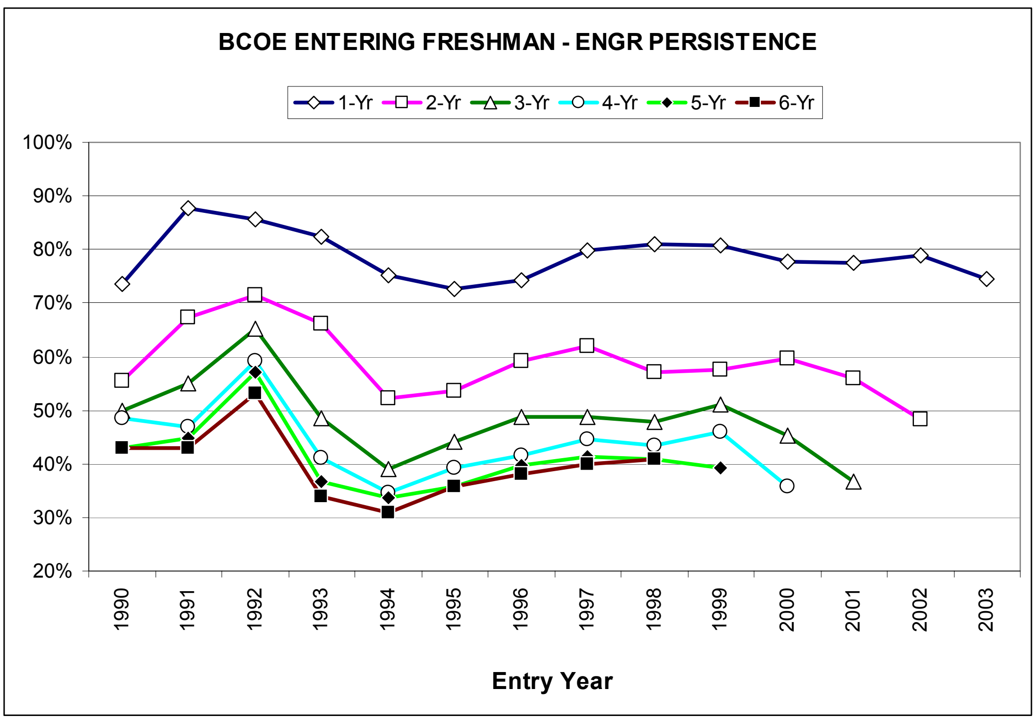


Figure 1. Persistence of entering freshmen in the Bourns College of Engineering.

Another consequence of this lack of engagement in the early years with the College is that our students do not appear to be building effective working relationships with their peers. They do not seem to see their peers as technically strong, or as effective partners. We see these attitudes clearly in the following summaries of responses to questions on the senior exit survey.

Questions Q028-Q030 on the senior exit survey asks students their level of satisfaction with their fellow students in terms of academic quality, ability to work in teams, and level of camaraderie. Question Q031 asks them how satisfied they were with the level of help in finding a permanent position. The satisfaction levels were to be rated numerically, with scores as follows: Very dissatisfied: 1, moderately dissatisfied:2, slightly dissatisfied: 3, neutral: 4, slightly satisfied: 5, moderately satisfied: 6, very satisfied: 7.

Figures 2 to 5 show the responses to question Q028-Q030. In each case, the responses correspond to a rating of "slightly satisfied." This is a surprisingly lukewarm rating, since they tend to be generally evenly matched in terms of abilities, as measured by metrics such as GPAs.

The College is addressing the deficiencies suggested by the charts above in several ways. The first of these is a series of 1-unit classes intended to promote engagement with the College in the early years and to help the student's professional development in later years.

This new series of classes, numbered ENGR 1 (freshmen), ENGR 2 (sophomores), ENGR 101 (juniors), and ENGR 102 (seniors) have now been approved, and we are currently in the process of tailoring the contents of these courses to our specific needs. These courses are intended to provide our students with involvement in Professional Development activities. Activities to be performed are program-specific, and will include projects, industry overviews and interactions, involvement with professional societies and clubs, team building, career guidance, and coverage of ethics and lifelong-learning issues

The specific list of topics in these courses will include the following:

- Participate in peer-group building activity.
- Understand engineering as a creative process for solving real-world problems.
- Understand current and future trends in the student's major discipline.
- Understand some analysis tools, and their use in design and practice.
- Understand the stages of development of an engineer as a professional.
- Participate in individual and group projects.
- Participate in professional clubs.
- Participate in the Career Path Milestones program.
- Understand the role and importance of ethics in the engineering profession.
- Understand the importance of engaging in life-long learning.
- Participate in industry visits.

The topics listed above will be presented in workshops and discussion-style activities. We expect that these courses will increase the degree of engagement of our students with our college, and promote academic and professional success.

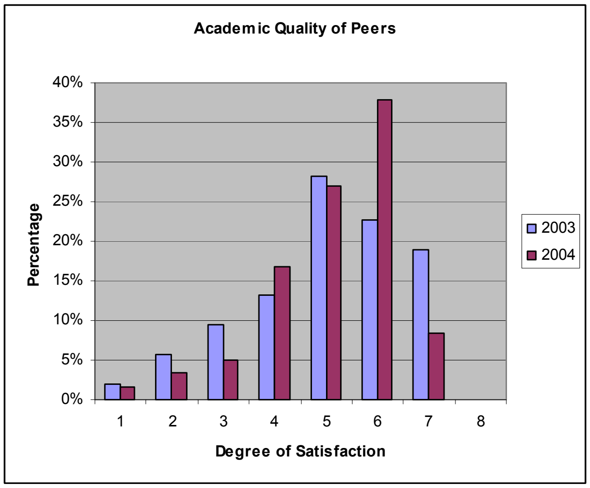


Figure 2. Student assessment of academic quality of peers.

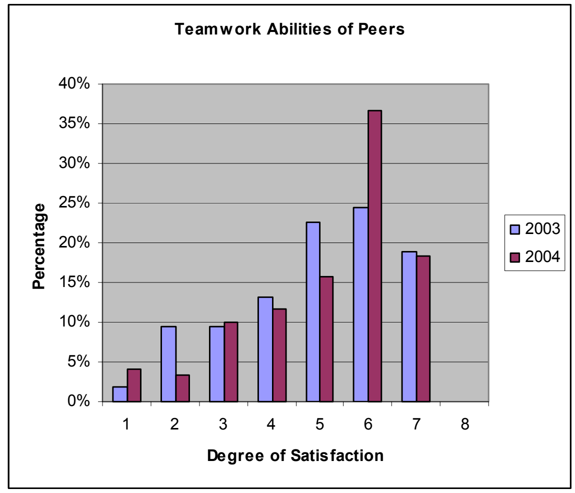


Figure 3. Student assessment of teamwork abilities of peers.

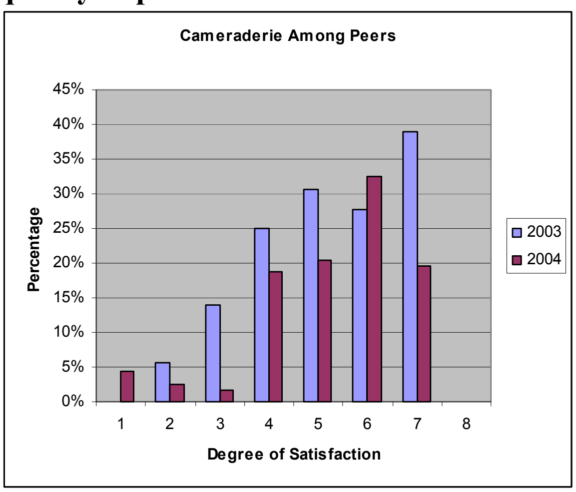


Figure 4. Student assessment of peer camaraderie.

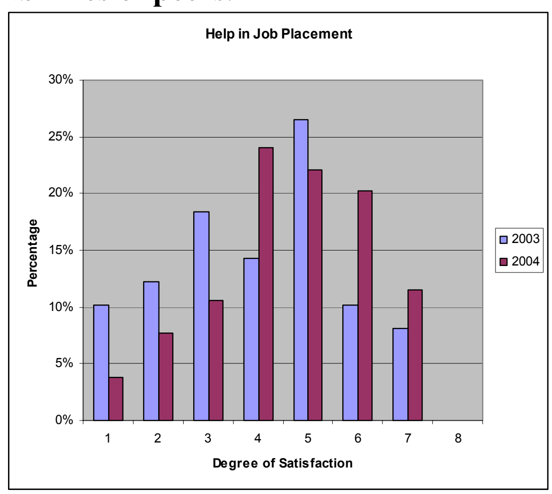


Figure 5. Student assessment of the College's helpfulness in job placement.

To further enhance the experience of our students in their early years, we also plan to restructure the freshman-level coursework in our programs to incorporate the notion of "learning communities," intended to consolidate further the opportunities for peer-group building that the ENGR 1-102 series of courses are intended to promote.

Since engineering freshmen constitute around 10% of the entering freshman pool each year, they also tend to constitute a small fraction of the enrollments in the freshman classes. Their numbers in these early classes are greatly diluted by the preponderance of students from other colleges, so their opportunities in these crucial early years to build social and academic peer groups with colleagues from the College are also correspondingly diminished.

As a result, the social circles of our undergraduates in their later years also tend to be formed mostly of students from the other colleges, particularly from humanities and social sciences, given their larger numbers on the campus. For various reasons, students from these other colleges appear to get by with significantly less work than is expected for engineering students, and serve as poor role models for undergraduates in engineering. Conversations with students in academic difficulty confirm this as a factor contributing to poor academic performance.

We plan to address this issue by clustering College undergraduates in freshman classes to form *Engineering Learning Communities*. Several conceptual implementations of learning communities are in use in engineering programs elsewhere, which we could use as possible models. However, since our freshmen take the bulk of their courses in the other colleges, we are working with the other colleges to develop a model for learning communities that would be most appropriate to our campus, We also intend our learning communities to work in tandem with the Professional Development and Mentoring curriculum.

In concept, our clustering program forms groups of freshmen and enrolls them in courses so groups, rather than individual students, are assigned to sections. Students will see the same set of peers in all their classes, and will be able to form stronger academic and social bonds with each other. Beginning in the fall of 2007, we will cluster our students in the following courses:

- Math 5: Sections 024, 025, 027.
- Math 8A: Section 005.
- Math 9A: Sections 011, 012, 013.
- Math 9B: Sections 031, 032.
- Math 9C: Section 004.
- Chemistry 1A: Sections 031, 027.

We are working with the Registrar's office to structure the freshman registration system so that incoming College freshmen are automatically enrolled in courses as groups. We plan to have the system in place by the fall 2006 quarter.

Another new initiative for 2007 is the Engineering Dormitory, *Enginuity Hall*. Sharing a common residential environment can be an effective means for enhancing the development of social and academic peer relationships.

An engineering residence hall will be an extension of the "learning communities" concept, and reinforce the benefits it is expected to yield. We plan to make academic and professional activities and integral part of the residential experience in this hall, hosting a range of activities such as professional club activities, office hours, study groups and supplemental instruction in the residence hall.

The initial reactions to this concept from the parents of incoming freshmen, from our current students, and our staff have been enthusiastic. It appears likely that we will get a sufficient number of students to make the pilot program successful.

We have been working with the Housing Services unit on campus to make the engineering residence hall option available to as many of our incoming freshmen as possible. We seem to be on target to have a pilot program in place by this fall quarter.

B.1.2 Student Advising

Student advising in the Bourns College of Engineering operates at three levels. First, staff Academic Advisors guide the students through planning, course selection, corrective action as needed, and degree check. Second, departmental faculty engage in group and individual student advising, as well as informal mentoring. Third, other resources from within the College and from the broader campus help students make good choices and advance successfully toward the degree. All of these mechanisms are covered in sections B.1.2 to B.1.4.

Students in the College of Engineering are assigned to an Academic Advisor in the Office of Student Academic Affairs based upon the year in school and/or their last name. Students are currently distributed between four sophomore through senior advisors and one freshman advisor.

Each advisor, with the exception of the Freshman Advisor, advises approximately 275 students each year. The Freshman Advisor is responsible for all new freshmen, in addition to continuing freshmen who have not yet earned enough units to achieve sophomore standing. As a result, the Freshman Advisor's caseload is larger than the others'. We are monitoring advisor caseloads, and plans call for the addition of another advisor and/or the addition of more support for the advising staff when the caseload reaches approximately 400.

The caseload system is designed so that students and Advisors have a relationship throughout the student's career. The Freshmen Advisor teaches the student how to navigate the University policies and procedures as well as teaches the student how to best utilize their Advisor and Faculty mentors skills.

At the start of the freshman year, each student is given a four-year course plan. Students are able to check their progress relative to this plan on-line at any time. In the spring of the freshman year, a student meets with his or her permanent staff advisor to discuss the fall schedule and make the transition to the Sophomore – Senior caseloads. The student now works with the same advisor on all academic issues through graduation. Course scheduling, academic difficulty counseling, petitions for exceptions, and graduation applications all come to the staff Advisor. This continuity allows the student and Advisor to develop a relationship of trust which leads to better service for the student and greater insight for the Advisor on the student's needs and ambitions.

It is the Student Affairs advisor's responsibility to monitor the progress toward completion of degree requirements. All of the engineering disciplines are patterned in sample program plans which form the basis of the four-year suggested course schedules. Advisors are able to assist students with creating a personalized plan to allow for actual course enrollment to vary from the standard plan, with the required courses to be rescheduled into a later term. This becomes particularly useful for students pursuing double majors, minors, changes in program, reduced course loads due to academic difficulty or extracurricular demands (e.g. employment), and students who have changed their major into the College of Engineering from another major on campus.

The Student Affairs advisors also perform a Satisfactory Academic Progress review annually, during the summer. Each student in the advisor's caseload is reviewed for degree progress. Students are counseled about course selection and academic support services to help them achieve better grades and get back on track with their Course Plan.

Prerequisites to courses are enforced by the Student Information System in accordance with the course approval forms. Should an instructor approve enrollment on an exception basis, the Student Affairs Officers can assist the student with enrollment, given reasonable written documentation (email, or note from the instructor). This documentation is then placed in the student's file.

Substitutions or waivers generally require the approval of the Associate Dean for Undergraduate Education or the Undergraduate Advisor in the major. Documentation of a substitution or waiver of a degree requirement is always included in the student's college file. Advisors are authorized to input the substitution or waiver into the Student Information System.

Technical electives required for the major are selected by the student in consultation with the faculty mentor or Undergraduate Advisor for their major. Several majors have developed focus areas to allow students to concentrate their studies in one particular area.

The ABET criteria are folded into the degree requirements. The completion of core requirements is monitored by the electronic degree check. The Humanities and Social Sciences requirements are also monitored by the electronic degree check. This process uses the approved breadth list to place completed courses into the appropriate categories for both breadth and depth. The only element which must be manually monitored is the aspect of the depth requirement which necessitates that one of the two upper-division courses be from the same area as another course.

Bourns College of Engineering Program for Students in Academic Difficulty

Students in academic difficulty are monitored by the Student Affairs advisors on behalf of the Associate Dean. Upon receipt of quarterly grades, the advisors review the academic records of students who achieve less than a 2.0 to determine whether the student should be placed on Academic Probation, placed on Continued Probation, or dismissed from the University. A student in danger of being dismissed has the opportunity to submit an appeal, which is then reviewed by the Associate Dean. If dismissal procedures must be instituted, this is done by the Associate Dean.

Because the College's Academic Difficulty policy only allows for two consecutive quarters in academic difficulty before the student is dismissed from the University, a multilayered process has been established to try and retain these students.

After grades are posted for a quarter, Academic Advisors manually place holds on the registration of each student in academic difficulty to prevent him/her from making any changes to his/her registration (University regulations limit such students to 13.0 units per quarter), for the upcoming quarter prior to completing difficulty procedures. Additionally, no later than the first week of the quarter, e-mail is sent to each student in difficulty to inform him/her of his/her status. The notification clearly states what the student must do to remove registration holds and restore good standing.

Each student in difficulty is required to attend an Academic Success Workshop. Workshops are offered during the first two weeks of every quarter. College offers a lower-division workshop for those students who have completed less than 90 units and/or no upper-division coursework. An upper-division workshop is offered for those students who are junior or seniors and well into their major having completed upper-division coursework. Approximately 80% of students in difficulty attend a workshop.

The Academic Success Workshop is designed to help students identify what it was that caused them to be in difficulty and equip them with strategies to rectify the problem and improve academic success. In the workshop, facilitators cover topics from how to identify and improve motivation to study strategies, and identify campus/college resources to facilitate the process of academic recovery. In the workshop, students are given a packet of materials to complete that includes an Academic Progress Review, Time Management Plan or Major GPA calculation (depending on class level), a Checklist that identifies various reasons why students end up in difficulty, and instructions for preparing a personal statement (essay).

If a student does not attend an Academic Success Workshop during the first two weeks of the quarter, he/she must then see an Academic Success Counselor (trained paraprofessional) to discuss all of the material covered in the workshop. The student still needs to complete all of the pieces of the packet as provided in the workshop. In addition, Success Counselors are available to all students throughout the quarter for advice.

A student must then set an appointment to meet with his/her academic advisor to discuss the various materials from the workshop and review the personal statement and checklist to further provide the student with support and strategies to resolve the issues that put him/her in academic jeopardy. The student is referred to appropriate campus resources such as the Counseling Center, Career Center, and Learning Center to meet with professionals with expertise to manage his/her personal issues surrounding academic difficulty. The student is also encouraged to visit his/her advisor prior to registration for the next quarter to discuss how things are going and plan an appropriate schedule. If the student does not complete all parts of the packet (time management plan, essay questions, etc.) the student is asked to complete the packet fully and return before the hold is removed. The advisor also reviews the student's complete grade history to be sure that the student is in a successful major choice.

Prior to registering for the subsequent quarter, a student in academic difficulty must complete a course plan and submit it to his/her academic advisor for review and approval. If the course plan is inappropriate the student is advised to come in for guidance or to given advice as to how to better select courses and asked to resubmit.

Additionally a student must complete a follow-up assessment to gauge how helpful the workshop was in helping him/her reach his/her goals for the quarter and if the student has been able to stick to his/her plan for success.

Students who wish, or need, to change their major are encouraged to contact their desired new department for advisory information.

About 80% of the students who are subject to the Academic Difficulty registration hold do agree to go through the process described above. Although we do not yet have benchmarking data, this process appears to be more effective than its predecessor, in which the student signed a "contract" to improve performance. Effectiveness is indicated either by a return to good standing in the Engineering program or successful transition to another major before the student's grade-point average is so low that remaining in the University is at risk.

Additional information about College's Academic Standing policy is available online at: http://www.engr.ucr.edu/studentaffairs/policies/acad_stand.shtml.

Bourns College of Engineering Faculty Mentoring Program

While Staff Academic Advisors in the Office of Student Affairs provide academic advising (guidance with registration, campus resources, course planning, etc.), Faculty Mentoring is a different kind of advising assistance. The Faculty Mentor's goal is to promote a strong relationship between students and professors in the department as early as the first quarter of the freshman year. Faculty Mentors are available for students to consult on matters pertaining to career planning, understanding engineering in general, and specifically for gaining a better appreciation of their major. Mentors also provide guidance on what it takes to be successful as an engineering student, and provide suggestions to enable students to gain confidence and self-motivation.

Faculty Mentoring is an opportunity for student and faculty to interact in a less intimidating situation. The program is designed for students to gain greater insight about classes and how course material relates to post graduate goals. This is the time for students to really understand how what they do in the classroom is connected to what Engineers actually do in the real world.

Faculty Mentoring helps students to clarify course guidelines, the syllabus, a specific assignment, lecture, discussion, and career goals; better understand comments on papers or assignments; improve grades by providing studying assistance; communicate about expectations; get advice on graduate study or future plans; and make suggestions for self-improvement.

All Bioengineering, Chemical Engineering, and Environmental Engineering majors, regardless of class level, are required to meet with their assigned Faculty Mentor as a condition of registration for every quarter of enrollment. In Chemical and Environmental Engineering, a typical quarterly advising meeting lasts 5-20 minutes depending on the needs. Usually, the Faculty Mentor start by reviewing the current achievements of the student. For freshmen and sophomores, the focus of the discussion is on basic science courses, stressing the importance of acquiring strong bases. Attempts are made to identify potential problems early. If possible, we strongly encourage students to follow plans that include three introductory chemical and environmental engineering courses in the sophomore year (CHE 110A, CHE 110B and CHE 122 for chemical engineers, and ENVE 171, CHE 100, CHE 130 for environmental engineers). Faculty stress the importance of taking the courses in the proper sequence. This is particularly important since ENVE/CHE courses are only offered once per year (which the exception of CEE 10/11). Options for lower division summer courses are discussed. For juniors and seniors, the focus of the conversation is on technical electives and as the students approach graduation, the mentoring shifts more towards professional and career advice. For all students, the importance of conducting research and participating in summer internships is emphasized. Students also have the opportunity to ask any questions to their faculty Mentor.

Computer Engineering, Computer Science, and Information Systems freshmen are required to meet with a Faculty Mentor in the first quarter of enrollment as a condition of registration. Electrical Engineering majors have access to a Faculty Mentor (Advisor) but are not required to meet on a formal basis. Freshmen in Mechanical Engineering are required to meet with their assigned Faculty Mentors as a condition of registration every quarter of their first year of enrollment.

Instructions for meeting with Faculty Mentors and contact information are provide via e-mail, posted on the College of Engineering Office of Student Academic Affairs' website and made available from each staff Academic Advisor. Students are encouraged to contact Faculty Mentors in person or by e-mail to schedule a mentoring session. Before the appointment, each student must obtain a Faculty Mentoring Confirmation slip from the respective department's administrative office. At the end of the meeting, the Faculty Mentor signs the confirmation slip verifying completion of the requirement. The student then brings the signed slip to the Office of Student Academic Affairs for removal of the registration hold.

B.1.3 Monitoring Student Credit-Hours

The College's Student Affairs advisors, Student Affairs Officers II, serve as both college office advisors and departmental advisors for each of the College's engineering disciplines. As departmental advisors, Student Affairs advisors discuss academic progress with students on a quarterly basis, and at additional times as changes warrant. Advising duties are split between freshmen and sophomore through senior students.

Freshman Advisor: Tara Brown

Sophomore – Senior Advisors:
A – F: Suzanne McCusker
G – K: Lisa Guethlein
L – P: Sonia De La Torre
Q – Z: Thomas McGraw

Since departmental and college advising is provided from one centralized staff, separate certification at the department level is not performed.

Once students file their Applications for Graduation (normally three weeks prior to the beginning of the graduation quarter), the Student Affairs Officer performs a preliminary degree check to assess completion of all University, College, major, and ABET requirements.

Students also have access to their own degree audit via a secure web interface. Bourns College of Engineering students are especially adept at utilizing this tool to assess their own degree progress. The audit takes the place of the preliminary as well as the final degree check that were formerly performed manually. As such, hardcopy tracking of graduation requirements is no longer done.

Upon receipt of final grades, a final degree check is performed, and students are cleared to graduate if they have satisfied all listed requirements. If the requirements are not satisfied, the student is notified by the Registrar's Office and asked to contact their College Office.

Transfer credit is honored and recognized for comparable subjects as determined by course articulation. Transfer credit is determined by faculty review. Each academic department has exclusive responsibility for the evaluation of transfer courses in its discipline, for the benefit of the campus as a whole. In each academic department, the Undergraduate Faculty Advisor is charged with reviewing any courses in their department submitted to the campus for consideration. Requests for course articulation are sent to the department by the Office of

Student Academic Affairs and are accompanied by a course syllabus, course description, course name and table of contents of the text, and any lab assignments. Courses are reviewed for comparability of engineering topics, lecture material, laboratory assignments (as appropriate), and prerequisites. In this way, each academic department is of service to the campus, and consistency is maintained. Individual academic departments do articulate courses outside their own field of expertise and recognizes the existing articulation completed by faculty in the respective academic departments. This ensures transfer credit for each student is treated equitably, regardless of the student's major.

The Office of Student Academic Affairs, specifically Thomas McGraw, maintains the documentation and collection of these course articulation requests within for College of Engineering on the campus Student Information System database. The campus Articulation Officer, Thea Labrenz, serves as the manager of this database of comparable courses, which interfaces with the statewide database, ASSIST, available via the World Wide Web. The database contains all approved comparable courses for use by all campus departments and California Community Colleges, and further contributes to consistency and efficiency.

B.1.4 Professional Development Milestones

The Bourns College of Engineering Professional Development Milestones program was designed to lead students to professional success after graduation. The Professional Development Milestones parallel a student's academic path and allow a student to plan and track his/her professional development as he/she would his/her academic progress.

Earning a college degree is no guarantee of professional success. Interpersonal skills, the ability to communicate effectively, leadership qualities, internship and/or research experience, networking skills, and many other characteristics determine professional success. The Bourns College of Engineering Professional Development Milestones program allows students to gain experience and develop the skills, abilities, and characteristics that determine professional success. Among other milestones, the Bourns College of Engineering strongly encourages all students to complete_at least one internship and at least one research experience prior to graduation. The Professional Development Milestones outline a plan that leads a student through each milestone and related activity as he/she makes progress toward professional success in graduate school, industry, research, academia, management, leadership, and/or many other professional endeavors.

The Professional Development Milestones program (formerly known as Career Path Milestones) is an interactive, web-based resource. The web site (http://www.engr.ucr.edu/studentaffairs/milestones/) maps actions that a student should take during each undergraduate quarter (Figure 6). Beginning in the freshman year, for example, it guides students to relevant professional organizations to join and resume-writing workshops. In the sophomore year, it connects students to resources for finding internships and research experiences. Other milestones include target dates for taking the GRE exam, revising resumes, and having mock job interviews.

At this time, Professional Development Milestones is used only for Bourns College of Engineering undergraduates. It is gradually expanding to other undergraduate sequences at UCR and other institutions, and eventually can be expanded to serve graduate students.

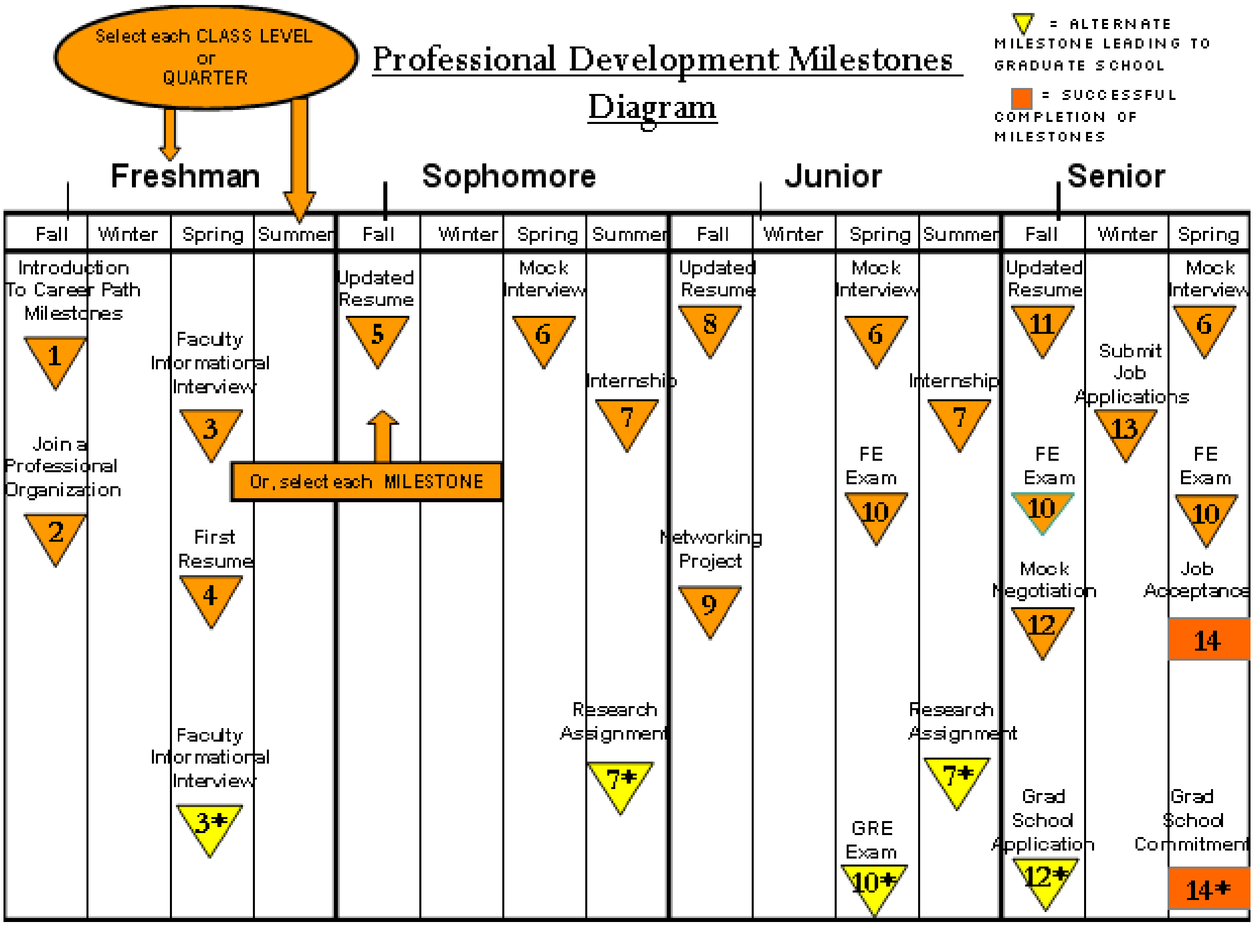


Figure 6. Diagram of key points during an undergraduate's tenure at which the Professional Development Milestones program prompts the student to take action in preparation for internships and academic or industrial career opportunities.

B.2 Program Educational Objectives

This section describes the Chemical Engineering degree Program Educational Objectives and their relationship to the institution's mission (Section B.2.1). Section B.2.2 lists the constituencies of the program and Department of Chemical and Environmental Engineering. Section B.2.3 sets forth the processes used to establish and review the Program Educational Objectives, and B.2.4 provides a detailed analysis of the relationship between each objective and the curriculum. Section B.2.5 discusses the extent to which the Department is achieving the Program Educational Objectives and the methods for reviewing progress and making changes. Finally, Section B.2.6 describes the mechanisms we have used to determine our success in achieving the objectives, and the results that those measurements have produced.

The vision of the Department of Chemical and Environmental Engineering over the next five years is to become one of the top 25 programs in both Chemical Engineering and Environmental Engineering in the nation.

We believe that the Department of Chemical and Environmental Engineering will be recognized for leadership in research and education that focuses on environmental quality improvements and innovations that improve the quality of life through the application of chemical engineering principles. The mission of the Department of Chemical and Environmental Engineering is to prepare students for professional practice, graduate study, and lifelong learning, and to advance the scientific and technological basis for chemical and environmental engineering practice.

Because of the rapidly changing technological society in which we live, today's chemical and environmental engineering graduates cannot be rooted into a single, standard mode of operation. They must be able to adapt readily to changing technologies and problem emphases, and develop creative solutions that are responsive to society as a whole. Thus, today's engineering students need to be rooted primarily in principles, not techniques.

The specific educational objectives (see http://www.cee.ucr.edu/abet/chem.shtml) of our chemical engineering program are to produce graduates who:

1. demonstrate the ability to apply mathematics, engineering principles, computer skills, and natural sciences to chemical engineering practice.
2. are capable of synthesizing principles and techniques from engineering, mathematics, engineering planning and project management and the natural and social sciences to develop and evaluate alternative design solutions to engineering problems with specific constraints.
3. are prepared for entry into careers in chemical engineering in the diverse areas including petrochemical and petroleum refining, bioengineering, semiconductor manufacturing, and food processing.
4. are prepared to pursue graduate education and research in chemical engineering at major research universities
5. exercise professional responsibility and sensitivity to a broad range of societal concerns, such as ethical, environmental, economic, regulatory, and global issues.
6. work effectively in a team environment, communicate well, and are aware of the necessity for personal and professional growth.

B.2.1 Relationship to University and College Missions

UCR's mission statement is as follows: The University of California, Riverside, is a research university committed to the creation and transmission of knowledge at the highest level, and to the translation of that knowledge for the public good. Our comprehensive programs and services, excellent faculty and staff, and vibrant and attractive physical environment are designed to: provide a high quality learning environment for undergraduate and graduate students; advance human knowledge and accomplishment through research and scholarship; enhance the public good through community service and initiatives; seek preeminence among U.S. research universities, recognizing UCR's quality in every area.

Superimposed over this mission are seven strategic goals articulated by Chancellor France Córdova:

1. To enhance UCR's reputational rankings: UCR will have the profile of an AAU member university.

2. To invest in areas of strength: UCR will be recognized for its distinction among all research universities in selected areas which exhibit quality and momentum.
3. To expand opportunities for learning and personal growth for all students, undergraduate and graduate: UCR will become a campus of "first choice" for applicants, and students will have a successful experience at UCR.
4. To reshape the curriculum: UCR will build on the diversity of its students and the distinction of its faculty, and connect the curriculum to the vision of UCR as an AAU institution.
5. To diversify our faculty, staff and graduate population: UCR will be a preeminent research university that has diversity as one of its measures of distinctiveness.
6. To build professional schools: UCR will offer expanded professional education in areas that respond to the needs of the state and region and that help to stimulate a knowledge-based economy.
7. To forge closer ties with the community: UCR will organize and coordinate with others to achieve common goals for prosperity and sustainability of the Inland Empire through technology transfer, attraction and retention of highly skilled jobs and industries, and responsiveness to regional issues.

The vision and mission of the Bourns College of Engineering is to become a nationally recognized leader in engineering research and education. The College's mission is to:

1. Produce engineers with the educational foundation and the adaptive skills to serve rapidly evolving technology industries.
2. Conduct nationally recognized engineering research focused at providing a technical edge for the U.S.
3. Contribute to knowledge in both fundamental and applied areas of engineering.
4. Provide a diverse curriculum that will instill our students with the imagination, talents, creativity and skills necessary for the varied and rapidly changing requirements of modern life and to enable them to serve in a wide variety of other fields that requires leadership, teamwork, decision making, and problem solving abilities.
5. Be a catalyst for industrial growth in the Inland Empire.

The components of the mission of the Bourns College of Engineering most relevant to the undergraduate program in Chemical Engineering are:

- To produce engineers with the educational foundation and the adaptive skills to serve rapidly evolving technology industries.

- To provide a diverse curriculum that will instill our students with the imagination, talents, creativity and skills necessary for the varied and rapidly changing requirements of modern life and to enable them to serve in a wide variety of other fields that requires leadership, teamwork, decision making, and problem solving abilities.

- To be a catalyst for industrial growth in the Inland Empire (see http://www.engr.ucr.edu/about/vision.shtml for complete vision and mission statement for the College).

The broad creation and transmission of knowledge in UCR's mission is consistent with the college mission to provide our students with a diverse curriculum that will engender their creativity in a rapidly changing environment. The college broad mission is to produce engineers who can function in technology industries. This enables translation of their knowledge for the good of the public, consistent with the University mission and the Chemical Engineering program educational objectives. The notion of engineers working successfully in interdisciplinary teams that require technical and non-technical expertise is emphasized in the college mission and in our program objectives. The program aims to offer ample opportunities for undergraduate research experience as a means to motivate graduates to pursue advanced graduate degrees in chemical engineering and other fields. Thus the program educational objectives are fully consistent with the mission of the Bourns College of Engineering and with the mission of the University of California, Riverside.

Educational objectives for the CHE program were set at its inception in the early 1990s. As the program evolved and matured, and as the curricula were adapted to better suit the needs of our students, our educational objectives were revised and adapted to best represent our programs and best serve our constituencies. In the process, CEE faculty and lecturers have developed program outcomes following ABET established guidelines, consistent with the program educational objectives. These are highlighted in Section B.3. A rational assessment process has been established to judge the extent to which program outcomes and educational objectives have been met. Assessment results are documented and used to improve the program to ensure closure of the assessment and improvement process. This ensures that the program educational objectives are consistent with the accreditation criteria.

B.2.2 Constituencies

The stakeholders of our program are Chemical Engineering undergraduate students, departmental faculty and lecturers, program alumni, employers in industry, and representatives from graduate schools. The Department of Chemical and Environmental Engineering has an Advisory Board that currently comprises 20-25 members from industry, regulatory agencies, and academia (see Table 2). The primary purpose of the Advisory Board is to provide insight and counsel to the Chair and CEE faculty in defining the future direction of the department, provide feedback on the curricula and degree programs (BS, MS, and PhD), and research directions. Typically, the Board convenes once each year for a day to discuss current issues. On occasion, the Chair may also call upon Board members for individual advice and input. Areas for which the Chair seeks such counsel include, but are not limited to educational needs, industry trends and needs, industry collaboration opportunities, centers of excellence, program expansion, industry recruitment process, internship and employment opportunities for CEE students, and assist as stakeholder in ABET accreditation process.

Table 2. Chemical and Environmental Engineering Advisory Board, 2006.

Name	Affiliation
Mr. Hans Kernkamp	Riverside County, Waste Management Department
Mr. Gerard Thibeault	California Regional Water Quality Control Board - Santa Ana Region
Prof. Shu Chien	UC San Diego
Prof. Harvey Blanch	UC Berkeley
Mr. Matt Chludzinski	Guidant
Dr. Meyya Meyyappan	NASA Ames Research Center
Dr. Jeffrey Mosher	National Water Research Institute
Dr. Sun Liang	Metropolitan Water District
Prof. Karen McDonald	UC Davis
Dr. Chung Liu	South Coast Air Quality Management District
Prof. Richard Flagan	Caltech
Dr. Farhad Adib	Bourns Inc. Materials Research Manager
Richard Wales	Mojave Desert Air Quality Management District
Dr. Brigette Rosendall	Advanced Simulation and Analysis, Bechtel National, Inc.
Dr. Scott Mansfield, PE	Jacobs Engineering (retired)
Ken K. Inouye	Chairman of the Board, Pacific Fuel Cell Corp.
Prof. Stanley Grant	UC Irvine
Victor Occiano	Brown and Caldwell, San Diego
Pete Wong, PE	Sr. Civil Engineer, City of San Diego, Metropolitan Wastewater Department EPMD
Chris Herencia, PE	Water Resources and Storm Water, Brown and Caldwell San Diego

B.2.3 Processes Used to Establish and Review the Program Educational Objectives

The current program educational objectives evolved from those set at the inception of the CHE program. Over the years, these educational objectives were modified, most importantly in 2000 and 2003. These objectives are published in the University Catalog and always available on our departmental web page (http://www.engr.ucr.edu/chemenv/). A summary of the procedures adopted to review and refine the program educational objectives and our assessment methodology is presented below:

Program educational objectives are formally reviewed by the CEE faculty annually at the departmental retreat (usually in September of each year).
During the academic year, our assessment procedure and a review of our overall objectives are carried out on a continuous and as-needed basis as part of the weekly or bi-weekly CEE Department faculty meetings, during CEE ABET meetings, or on a College-wide basis during the BCOE ABET Committee meetings.
The educational objectives are presented and discussed during the meetings with the Advisory Board.
Program educational objectives guide our assessment process review at faculty meetings (monthly during the 9 month academic year).

The following text was first published in the 2003-2004 UCR catalog describing our original program educational objectives. These goals, and the specific goals that follow, were adopted based on internal faculty discussion and consultation with our stakeholders, in particular the CEE faculty together with our alumni and our advisory board.

Chemical Engineering focuses on transforming raw materials into useful everyday products. Chemical engineers turn the discoveries of chemists and physicists into commercial realities. They find work in a variety of fields including pharmaceuticals, materials, chemical, fuels, pollution control, medicine, and nuclear and electronic industries. At UCR, the B.S. degree in Chemical Engineering offers students three options: Biochemical Engineering, focusing on biochemical processes; Bioengineering, focusing on the biomedical industry; or Chemical Engineering, emphasizing traditional chemical engineering issues. The goals of the major are to:

• *instill graduates with principles that will enable them to analyze and solve a wide range of problems and situations facing chemical engineers today and in the future*

• *provide students with the skills necessary to meet the challenges of modern engineering practice*

• *provide a high-quality undergraduate education necessary for a student to advance to the graduate level*

The goals listed in the catalog represented the original broad goals of the major. In 2003, these educational objectives were expanded and refined into six specific educational objectives for monitoring and assessment (see http://www.cee.ucr.edu/abet/chem.shtml). The 2003 changes were motivated by several factors which included the exit comments from the 2000 ABET review, a complete review of the chemical engineering curriculum by the CEE faculty, discussions with our alumni, current students and Advisory Board, and a review of the new ABET requirements. Changes were discussed during the calendar year 2001 and were submitted for various campus approvals early 2002. They took effect for the 2003 catalog year. The curriculum and educational objectives have remained essentially unchanged since then. Educational objectives were slightly reworded in the printed catalog effective 2006-2007. Most recently, the educational objectives were discussed with the advisory board at the 2006 annual meeting. The board reaffirmed its support and endorsement of our educational objectives.

The specific objectives of our chemical engineering program are to produce graduates who:

1. demonstrate the ability to apply mathematics, engineering principles, computer skills, and natural sciences to chemical engineering practice.
2. are capable of synthesizing principles and techniques from engineering, mathematics, engineering planning and project management and the natural and social sciences to develop and evaluate alternative design solutions to engineering problems with specific constraints.
3. are prepared for entry into careers in chemical engineering in the diverse areas including petrochemical and petroleum refining, bioengineering, semiconductor manufacturing, and food processing.
4. are prepared to pursue graduate education and research in chemical engineering at major research universities
5. exercise professional responsibility and sensitivity to a broad range of societal concerns, such as ethical, environmental, economic, regulatory, and global issues.
6. work effectively in a team environment, communicate well, and are aware of the necessity for personal and professional growth.

Assessment of the degree to which these educational objectives are met is made by various methods, of which surveys from our current students, alumni, and employer constituencies play a major role. In the past 3 years, we have developed a web-based survey in which e-mails are sent to alumni and industry employers asking them to respond to questions that can be accessed through a link in the e-mail. The survey website is maintained at the college level (http://www.engr.ucr.edu/abet2000/stats/). The response rate to date has been relatively small, as can be seen in the figures below. This is in part due to the limited size of the CHE alumni pool (121 graduates since the first graduating class in 1994) and the fact that the alumni database, which was maintained outside the department, was outdated and not being well maintained. Changes are being made to ensure our requests will reach our alumni in the future.

A part of this survey asked the alumni to evaluate the relevance of the six CHE educational objectives. Figure 7 summarizes of the responses to each objective. It appears that there is good general buy-in of the CHE program objectives with most scores in the 4-5 category, except for two outliers always scoring low. The lowest buy-in score was for Objective 4 (being prepared to pursue graduate education) which may reflect the fact that generally, about half the students intend to work rather than attend graduate school. Clearly, a larger response would be desirable for a strong statistical analysis of the data. Even so, the faculty is confident that there is broad support of the six CHE objectives.

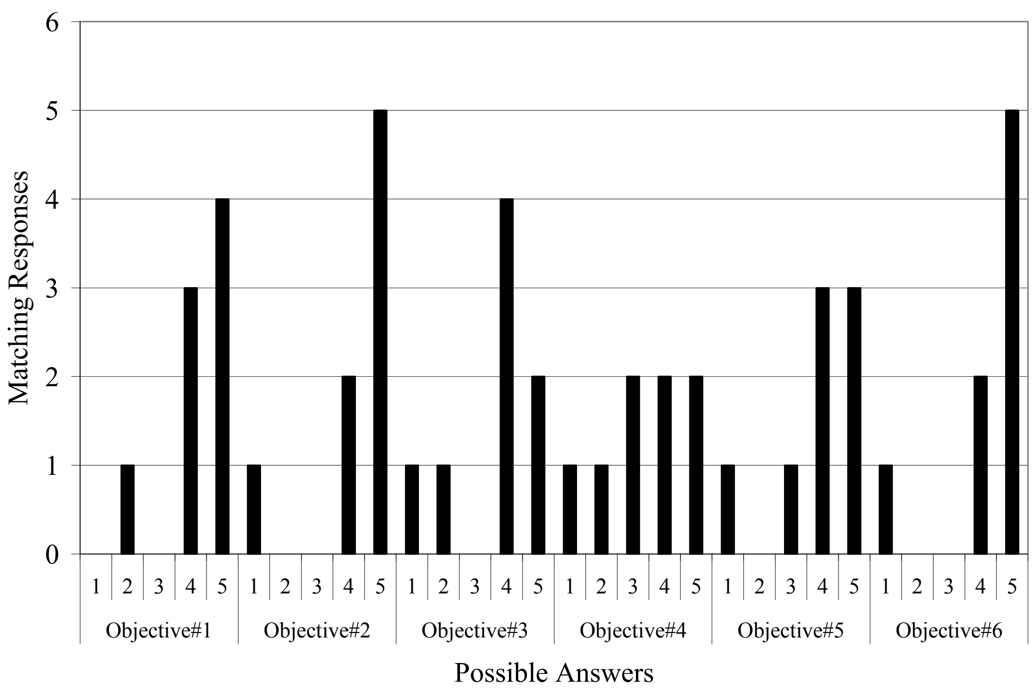


Figure 7. Alumni survey response on the relevance of the six CHE objectives. (See above for the complete wording of the objectives.) 1=not relevant; 5=highly relevant objective.

B.2.4 Program Curriculum and Its Relationship to Program Educational Objectives

A detailed curriculum is presented in Appendix I. The Chemical Engineering Educational Objectives presented earlier in this section are broadly met through a curriculum that offers:

- A well-rounded and balanced education achieved through required studies in selected areas of the Humanities and Social Sciences.
- Strong training in the areas of mathematics, science, and the fundamentals of chemical engineering that constitute the foundation of the discipline.
- Extensive laboratory and hands-on experience to strengthen understanding of fundamental principles, with opportunities for team work, written, and oral communication.
- Use of computer simulation and modeling in problem solving and in design.
- Application of knowledge to design problems common to modern chemical engineering practice.
- Introduction of design for manufacturability, engineering economics, and engineering ethics into the curriculum to emphasize the relationship between design, fabrication, cost, and impact on society.
- Freedom for the student to mold his or her program of professional specialty studies by allowing each student to choose between three options (traditional chemical engineering, biochemical engineering and bioengineering), and also choose from a number of technical electives, including credit for independent research, and offering a selection of senior design capstone projects sponsored by faculty and relevant to industrial sponsors.

The relationship between each program educational objective and the curriculum is discussed in some detail below.

Educational objective 1: Produce graduates who demonstrate the ability to apply mathematics, engineering principles, computer skills, and natural sciences to chemical engineering practice

In addition to basic courses in Mathematics (MATH 009A, MATH 009B, MATH 009C, MATH 010A, MATH 010B, MATH 046), Chemistry (CHEM 001A, CHEM 001B, CHEM 001C, CHEM 112A, CHEM 112B, CHEM 112C), Physics (PHYS 040A, PHYS 040B, PHYS 040C), and Biology (BIOL 005A, BIOL 05LA), students acquire skills in chemical engineering sciences including process analysis (CHE 110A and CHE 110B), chemical reaction engineering (CHE122), fluid mechanics (CHE 114), heat transfer (CHE 116), mass transfer (CHE 120), separation processes (CHE 117), process control (CHE 118), thermodynamics (CHE 100 and CHE 130), engineering modeling and numerical techniques (ENGR 118), and design (as elements in numerous courses and CHE 175A and 175B). Additional technical electives differentiate the chemical engineering, biochemical engineering and bioengineering options with all of the three options building a core foundation for their specific emphasis. These are reinforced through two major laboratories focused on data acquisition and advanced experimentation (CHE 160ABC series for all options, CEE 125 for Chemical Engineering and CHE 124L for Biochemical and Bioengineering options). The program culminates in a capstone senior design project (ChE 175AB) while training students on design methodologies, engineering economics, and engineering ethics. The concept of design, modeling, and analysis is emphasized starting with the freshman course, Introduction to Chemical and Environmental Engineering (CEE 10/11), and continues throughout the curricula thereby adequately preparing our students to enter a variety of industries.

Educational objective 2: Produce graduates who are capable of synthesizing principles and techniques from engineering, mathematics, engineering planning and project management and the natural and social sciences to develop and evaluate alternative design solutions to engineering problems with specific constraints

This key objective is also addressed throughout the chemical engineering curricula. This objective is generally addressed through fundamental training in mathematics, sciences and engineering principles (overlapping with objective #1). The objective is specifically addressed within the design components of the upper division engineering courses. Most courses in the CHE curriculum have one or several associated mini-design projects that require the students to synthesize the engineering principles covered in the course to address current chemical engineering concerns under constraints identified within the design problem (often laid out by the students themselves). In most core required courses such as transport, thermodynamics, and kinetics, students are require to solve engineering problems specific to the topic of the course. In upper division courses (e.g., CHE 117 Separation Processes, CHE 118 Process Control), the problem solving becomes more sophisticated, e.g., requiring an iterative process or a numerical solution, and the problems often include an added dimension (evaluate an alternative design or compare results with an approximate method). Engineering planning and project management as well as inclusion of the natural and social sciences is primarily concentrated in the senior design project (CHE 175AB), which requires to discuss the economic (as well as time constrained) viability of their designs. Examples will be presented in the course files available during the site visit.

Educational objective 3: Produce graduates who are prepared for entry into careers in chemical engineering in the diverse areas including petrochemical and petroleum refining, bioengineering, semiconductor manufacturing, and food processing

Science and engineering courses discussed in the context of objectives #1 and #2 provide students with disciplinary intellectual rigor required to succeed in industry. In order to be prepared to careers in a variety of disciplines, our program is not rooted into a single, standard mode of operation. The focus is primarily on principles which allow graduates to adapt. Training include the ability to formulate problems, make and test assumptions, predict and solve problems which all enable students to succeed in the field of chemical engineering. Fundamental problem solving skills developed throughout the curricula are applied in all options. The students further pursue their emphasis through additional technical elective courses. The laboratory courses (CHE 160ABC) ensure that the student is trained for laboratory work within their discipline while the capstone senior design project is designed to emulate problems that will be encountered within the students career. CEE 158 (Professional Development for Engineers) exposes the students to a variety of topics and issues, including professional registration, ethics, risk management and environmental health and safety, and regulatory issues.

Educational objective 4: Produce graduates who are prepared to pursue graduate education and research in chemical engineering at major research universities

The technical rigor required to pursue advanced graduate degrees in chemical engineering and other related fields is emphasized in our basic curriculum. Additionally, the CHE 190 Special Studies series courses (1-5 units) allow the students to take for credit independent studies where students work on research projects individually or in small teams with a faculty mentor. Additionally, undergraduate research is strongly encouraged within our program with a large fraction of students participating in research programs. These programs include the research advancement program (RAP), where incoming freshman have the opportunity to work in research laboratories (see Appendix II). This program is designed to foster interest in CHE research with the students performing extensive literature searches/reviews during their first year with an oral presentation at the end of their first year. The students are then expected to continue their research development in their second through fourth year within the laboratory. This program leads to well trained and prepared students for the research component of graduate education at major research universities. The department does not keep track of the number of CHE undergraduate students conducting research either as paid research assistant, summer trainees, or volunteers in the CEE department. An estimate is that about 50-80% of the CHE graduates have at some point conducted research in our laboratories. Often, they reach meaningful accomplishments resulting in co-authorship in peer-reviewed journal articles, and/or posters or presentations at local conferences. The campus has a minigrant ($400-800) program to foster undergraduate research. Several of our students have applied and obtained funding through that program.

Educational objective 5: Produce graduates who exercise professional responsibility and sensitivity to a broad range of societal concerns, such as ethical, environmental, economic, regulatory, and global issues

This objective is primarily met in the introductory courses (CEE 10/11), the professional development course (CEE 158), and the senior design project (CHE 175AB). CEE 158 was a course that was added to the 2003 curriculum to directly address this objective after a review by CEE faculty identified that professional and ethical issues had not been adequately covered previously. Additional reinforcement of these concepts was broadly covered in the upper division CHE courses.

English 1B, a freshman course, also includes readings and writings on social responsibilities. The course curriculum includes a writing assignment in which the student assesses an individual's duty to the state, the government's duty to the people, and the positive and negative impacts of technology on changing the world.

Educational objective 6: Produce graduates work effectively in a team environment, communicate well, and are aware of the necessity for personal and professional growth

The importance of teamwork is emphasized in the student's very first quarter (CEE 10/11). In subsequent quarters, students are required to work in teams (laboratory courses CHE 160ABC, numerous course specific team mini-design projects, e.g., CHE 102 and Senior Design courses CHE 175A/B. Other examples include team problem solving in the classroom (e.g., routinely conducted in CHE 120 Mass Transfer). The program culminates with a significant team project undertaken by students as part of the senior design sequence (CHE 175AB) in the final year.

The majority of the upper-division engineering courses in the Chemical Engineering program place some emphasis on the importance of good communication skills. Opportunities to practice these skills include group discussions in class, written reports for laboratories or design projects, and oral presentations. Laboratory-based courses require students to submit written reports of their experiments and findings. Laboratory grades are based not only upon the technical contents of the reports, but also on the student's presentation. Students are provided with guidelines and support for writing their technical reports and for their oral presentations.

The awareness of the necessity for personal and professional growth is emphasized mostly in CEE 158 (Professional Development for Engineers), in senior design (CHE 175AB) and during the mandatory quarterly advising meetings of the students with their faculty advisers. The students are encouraged to become active professionally through activities which include participation in the various student chapters (e.g., AIChE), taking the FE exam, attending local meetings of professional societies, or local scientific meetings, interacting with the local professional community, attending seminars, etc. The department offers support either to invite speakers for seminars, for transportation, for students to participate in local meetings, and for registration and transportation for students to attend local conferences or other events that are beneficial to their professional development.

B.2.5 Achievement of Program Educational Objectives and Program Review

The CHE program has been reviewed on a regular basis since it was founded in 1992. ABET accreditation visits took place in 1994 and in 2000. The review of the educational objectives and of the program has been a continuous process, conducted mostly by the CEE faculty (at faculty meetings, meetings of the undergraduate education and CEE ABET Committees, and CEE faculty retreat) and by the Advisory Board, yearly or bi-yearly.

The current set of educational objectives was revised to be consistent with the program goals of the department and the ABET criteria. These objectives were formulated by the ABET Committee and then voted upon by the department faculty in 2003. These objectives are revisited each year within the departmental meeting at the annual faculty retreat and at the department board of advisors. No significant changes have been made to these objectives since their 2003 formulation.

More recently, an alumni survey has been conducted to provide feedback from this key constituency on the attainment of the CHE objectives. An online survey was developed in which alumni are sent e-mails periodically to respond to questions related to the program. These results are reviewed by the faculty to make improvements in the program. One limitation of this survey is the relatively small size of the CHE alumni base, which has led to limited feedback at this time. However, even the limited response provides some insight in the programs ability to meet these objectives. It is understood that the alumni response will show slower responses to programmatic changes (timescale of 5-10 years). Figure 8 summarizes the responses to the survey. Responses could range from 1 to 5 with a 5 indicating that the respondent strongly agreed with the objective.

The poll indicates an overall positive response from the CHE alumni with average responses for the objectives ranging from 2.7 (objective #6) to 4.0 (objective #2). The low score (2.7) on objective #6 *(Produce graduates work effectively in a team environment, communicate well, and are aware of the necessity for personal and professional growth)* was somewhat surprising to us, as many of our courses require team work, and training to achieve good communication skills is practiced throughout the curriculum. Stressing the awareness of the necessity for personal and professional growth has been addressed recently by adding CEE 158 (Professional Development for Engineers). Objective #5 (*Produce graduates who exercise professional responsibility and sensitivity to a broad range of societal concerns, such as ethical, environmental, economic, regulatory, and global issues*), the second-lowest score, was most recently addressed in the CHE curriculum through the addition of CEE 10/11 and CEE 158. These courses will first be completed as required curriculum by all students the exiting class of 2006 (many but not all alumni have already graduated with the CEE 10/11 and 158 requirements), so the changes to the curricula are not fully apparent in the alumni survey. The ABET Committee suggested continued monitoring of objectives #5 and #6 to see if recent programmatic changes will have addressed this apparent shortcoming. Extensive discussions also led to the general conclusion among the CEE faculty that while the numbers were informative, better data were needed to improve the statistical relevance of the survey. In the meantime, careful and close monitoring of all objectives will be conducted.

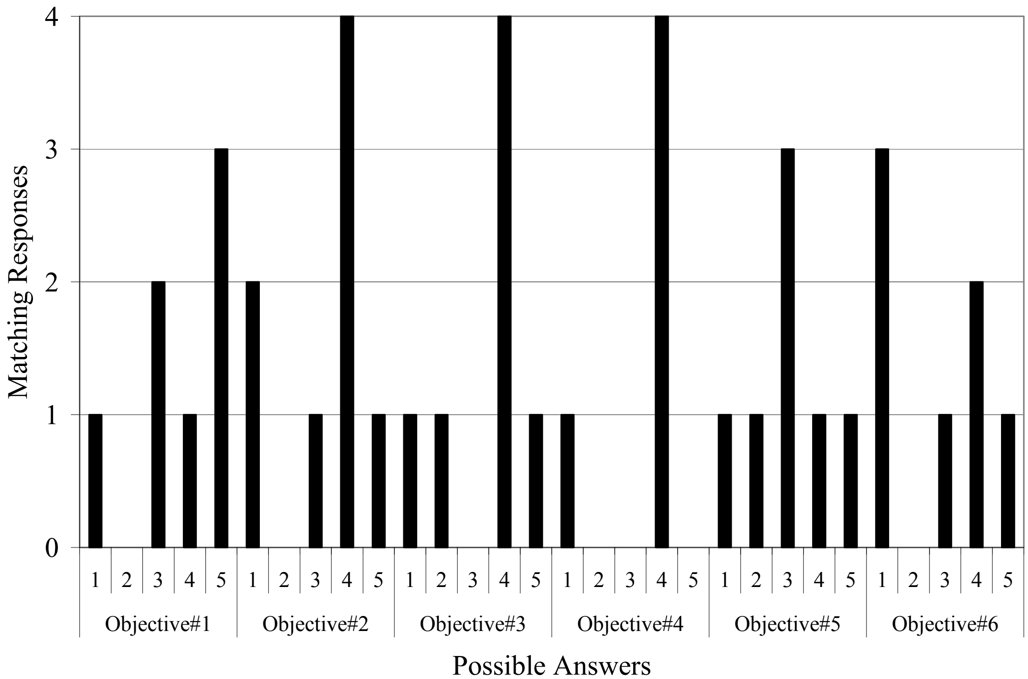


Figure 8. Alumni survey response on the <u>attainment</u> of the six CHE objectives. (see Section B.2.3 for the complete wording of the objectives). 1=not attained; 5=Very well attained.

The Bourns College of Engineering initiated a college-wide alumni survey (not to be mistaken with the senior exit survey) in 2006 to uniformly determine how well our graduates are achieving our program objectives. The College has approximately 600 alumni who graduated between 2000 and 2003, and who thus are in that "window" of interest to ABET – three to five years after completion of the bachelor's degree. We use a single survey tool for all alumni. It is designed to quantify the extent to which our alumni are achieving objectives common to all of the College's degree programs; these include the ability to succeed in graduate school, the ability to succeed in industry, the ability to work in teams, the ability to apply mathematics and engineering principles on the job, and the ability to contribute to the profession through inventions and publications. The current methodology begins with an e-mail message from the dean to the target alumni, followed by a second e-mail containing the actual survey. College staff then follow up by phoning those who do not respond.

The response to the alumni survey so far has been low – less than 10%. Going forward, we expect to increase the response rate by (1) working with UCR's alumni relations office to improve our contact database and (2) making more contacts via phone or a web-based interface. Since each alumnus will be in the survey "window" for three years and the overall population is relatively small, we are confident of obtaining data on a very high percentage of alumni at least once in the five years after graduation. This will provide us with good, quantifiable data on the performance of our alumni with respect to our program objectives. It should be noted, however, that the survey results will always be a trailing indicator because of the long lag time between a change to the curriculum and the ability to measure what impact it has on our alumni's success and effectiveness three to five years after graduation.

Based on the limited returns from the pilot study in 2006, we are seeing high proportions of our alumni achieving the prescribed degree objectives (Table 3). The survey, the tabulated results, and the written comments of the respondents will be available for review during the site visit.

from 11 alumni out of 63 graduates (covering the past four graduation years). The CHE alumni response indicates that a significant number (5 out of 11) of students pursued higher educational degrees (objective #4) point to a desire for strong life-long learning. The ABET Committee was very happy to see that 9 of those responding indicated that the knowledge obtained from their UCR education has provided them with the knowledge to successfully conduct their duties including multi-disciplinary teamwork (objective #2), professional and ethical responsibilities (objective #5), and the ability to apply math, engineering principles, computer skills, and natural sciences (objective #1). Most alumni who responded currently are members of professional societies and subscribe to professional publications/journals (objective #6), and all those who had taken the FE exam (9 out of 11) had passed. About half had contributed to developing new intellectual property. A majority of responding alumni were employed in their field of choice and had been promoted since joining their work (objective #3). The salary ranges are also indicative of professional success. (objective #3), three of the respondent were earning more than $125k per year.

The department will continue to pursue methods to achieve higher response rates of alumni in the upcoming years including better tracking of alumni e-mail changes and current phone numbers. The yearly advising meeting for current students was also used to stress to the student body the importance of continued contact with UCR and the value of the alumni (and current student) surveys.

Table 3. Results of 2006 Bourns College of Engineering alumni survey.

Metric	% of alumni answering yes
Took admissions test in pursuit of a postgraduate degree	>60
Was accepted to graduate school	~75
Plan to attend, is attending, or has attended graduate school	~70
Have completed an advanced degree	~20
Accepted a job offer within three months of graduation	>60
Accepted a position related to the engineering degree earned	80
Had a starting salary in the range of $40,000 to $60,000	50
Currently earning more than $75,000	>30
Still working in the field in which the engineering degree was earned	80
Have worked on projects with multidisciplinary requirements	70
Have worked on projects that have addressed professional and ethical concerns	60
Are required to apply mathematics and engineering principles on the job	>90
Consider the UCR education reasonably sufficient to conduct their duties	~90
Have collaborated on projects leading to patents or other types of disclosures	40
Have published in professional journals	~30

The response rate for CHE was significantly better than the rest of the college with responses
An employer survey was also conducted in spring 2006 to evaluate employers' assessment of CHE student achievement of the key 6 educational objectives for CHE. This was a short questionnaire in which the employers were asked to rate the students achievement of each educational objective from 1 (lowest) to 5 (highest). A limitation was that we only had detailed employer information for 32 alumni, out of 121 all time CHE graduates. The response rate was fair with responses received from 17 CHE alumni employers (9 in academia, 8 in industry). The results are tabulated below (Table 4). Figure 9 displays a histogram of employers ratings of ENVE alumni achievement of objectives.:

Table 4. Achievement of CHE objectives by our alumni, as assessed by their employers.

	Mean	Stdev
Objective 1	4.18	0.64
Objective 2	4.35	0.86
Objective 3	4.24	0.75
Objective 4	4.24	0.75
Objective 5	4.41	0.62
Objective 6	4.47	0.62

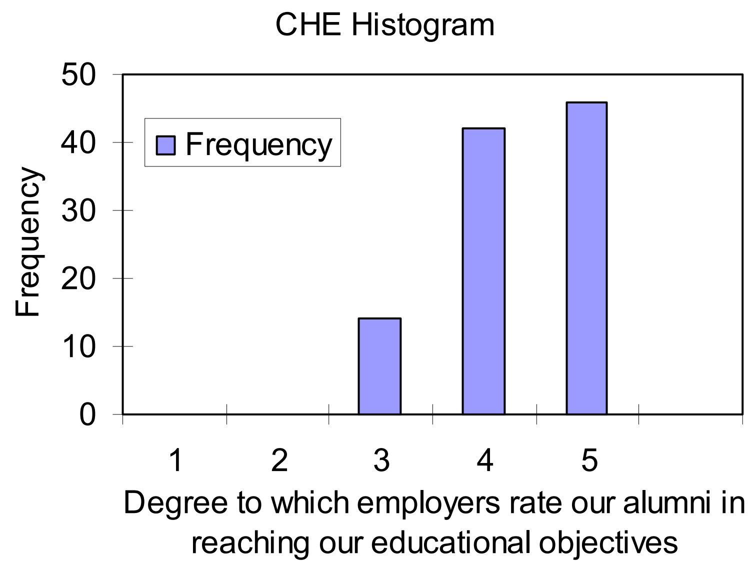


Figure 9. Employer ratings of CHE alumni achievement of educational objectives. Since there was little difference in reaching each one of our six educational objectives, the ratings were merged to show a compounded distribution.

The employers of CHE alumni appear to be generally very satisfied with their achievement of the six educational objectives with mean achievements greater than 4.2 out 5 for all six educational program objectives. A few comments were made:

- "Writing skills need to be improved."
- "I think more effort is needed in the program to expose students to actual industrial locations and processing equipment."
- "I am extremely happy with [employee name removed] performance. He is becoming one of my key employee. I am considering to promote him within this year."

The importance of good writing skills was also stressed by the Advisory Board and CEE faculty will be looking into this issue as well as assessing the need for increasing exposure of our students to real plants, processes and equipment, in summer 2006. Continued monitoring and survey of the UCR alumni employers will be pursued in the future.

B.3 Program Outcomes and Assessment

This section describes our Program Outcomes (Section B.3.1) and their relation to the Program Educational Objectives (B.3.2). Section B.3.3 describes our process for evaluating outcomes, as well as the process by which the assessment results are applied to further develop and improve the program. Section B.3.4 describes evaluation of our results, and B.3.5 describes changes that we have made to the program in response to the assessments. Finally, Section B.3.6 identifies the materials that will be available to examiners during the site visit.

B.3.1 Program Outcomes

Graduates of the Chemical Engineering program must demonstrate:

Ability to apply knowledge of mathematics, science and engineering.
Ability to design and conduct experiments, as well as analyze and interpret data.
Ability to design a system, component, or process to meet desired needs with realistic constraints such as economic, social, political, ethical, health and safety, manufacturability, and sustainability.
Ability to function on multidisciplinary teams.
Ability to identify, formulate, and solve engineering problems.
Understanding of professional and ethical responsibility.
Ability to communicate effectively.
A broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
Recognition of the need for and an ability to engage in lifelong learning.
Knowledge of contemporary issues.
Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

B.3.2 Relation between Program Outcomes and Educational Objectives

Several discussions were conducted, both formally and informally, among members of the stakeholder groups to establish consistency between program objectives and program outcomes. The current set of objectives is the result of a meeting of the stakeholder group held in May 2004. The current set of objectives is to produce graduates who:

1. demonstrate the ability to apply mathematics, engineering principles, computer skills, and natural sciences to chemical engineering practice.

2. are capable of synthesizing principles and techniques from engineering, mathematics, engineering planning and project management and the natural and social sciences to develop and evaluate alternative design solutions to engineering problems with specific constraints.

3. are prepared for entry into careers in chemical engineering in the diverse areas including petrochemical and petroleum refining, bioengineering, semiconductor manufacturing, and food processing.

4. are prepared to pursue graduate education and research in chemical engineering at major research universities

5. exercise professional responsibility and sensitivity to a broad range of societal concerns, such as ethical, environmental, economic, regulatory, and global issues.

6. work effectively in a team environment, communicate well, and are aware of the necessity for personal and professional growth.

The program outcomes are related qualitatively to program objectives through the “influence” matrix shown in Figure 10.

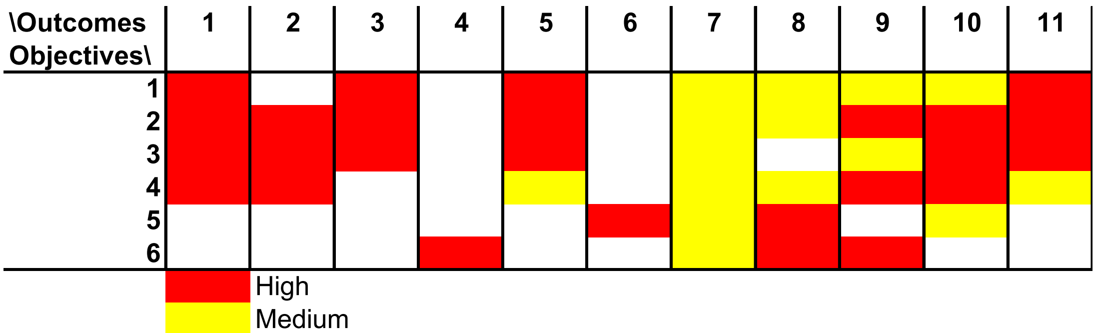


Figure 10. Correlation of our 6 educational objectives to the 11 outcomes.

The figure demonstrates how each objective is tied to each of the ABET outcomes. The strength of the relationship between objectives and outcomes is classified as either high (Red), medium (Yellow), or low (no color). Educational objectives 1-4 focus more on the technical aspects of the engineering discipline with emphasis on problem solving, data analysis, design, and application of tools (outcomes 1, 2, 3, 5, 11). Outcome 4 is best captured by educational objective #6 while outcome 5 is best captured by educational objective #5. Outcome 7, ability to effectively communicate, is captured throughout all objectives. Outcomes 8, is best captured in objectives #5 and #6, while outcome 9 is covered in objectives #4 and #6, and outcome 10 is best covered in objectives #1-#3. It is important to note that all outcomes are related to the educational objectives, with many objectives addressing a number of the outcomes simultaneously.

B.3.3 Assessment of Program Outcomes

We have implemented multiple feedback loops used to “foster the systematic improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment” (From Criteria for Accrediting Engineering Programs, ABET, EAC, November, 2004). An overview of the system used by the CHE program to foster systematic improvement is provided in Figure 11. The yellow boxes refer to the processes used in the system, while the blue boxes refer to the “objects” that these processes operate on. This system was designed at the college level and is identical for all programs.

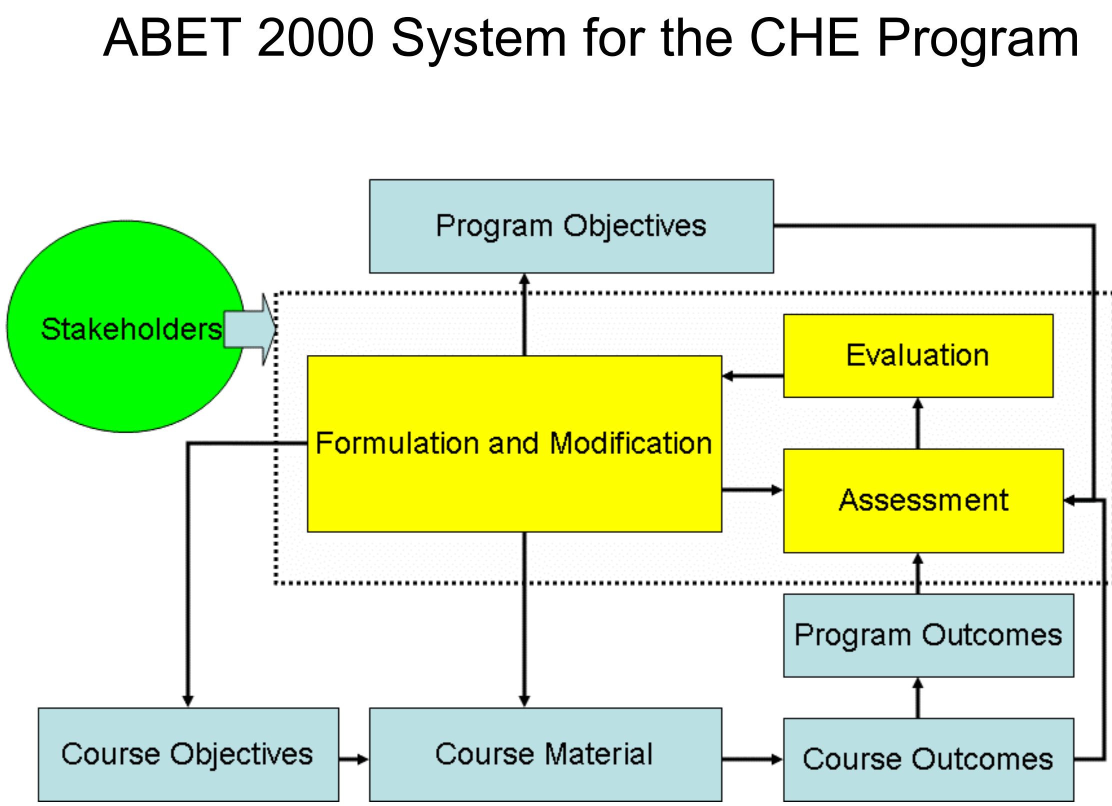


Figure 11. Chemical Engineering program system for course improvement.

Course objectives are formulated to yield course outcomes, which in turn produce program outcomes. The program outcomes are designed to foster attainment of program objectives.

The outcomes are ***assessed*** to produce qualitative and quantitative measures of performance. These measures are then ***evaluated*** against metrics. This process leads to the ***modification*** of a variety of components of the educational process to improve the effectiveness of attaining program outcomes and objectives. These processes are carried out by a stakeholder group consisting of faculty members, undergraduate students, alumni, faculty members from other schools, industry employers.

Through discussions with the stakeholders of the department, the CEE ABET Committee and the CEE faculty identified and adopted the program outcomes consistent with Criterion 3 of the Engineering Accreditation Criteria; specifically, no additional outcomes were added. The list of outcomes is provided in Section B.3.1.

The most immediate and specific feedback loop is at the course level using the course matrix, which includes course objectives linked to desired outcomes, student feedback and student grades. The course instructor is required to assess the course after completion of the quarter and make specific recommendation to improve the course for the following year. This assessment integrates the professor's goal, student feedback (student survey of their evaluation of meeting course objectives), the matrix of course objectives linked to desired outcomes and grades, and the personal evaluation of the instructor. Upon review of the matrix, a threshold score of 70% for either student feedback or student grades usually *requires* a *documented* action to improve the course. The 70% threshold was set as a course benchmark based on extensive discussions among the CEE ABET Committee.

The annual summary of the matrices is then evaluated by the ABET subcommittee, which reports its findings and recommendations to the entire department. The required actions are discussed collectively among the CEE faculty and/or within the ABET subcommittee. As an example, Figure 12 shows the assessment for all non-technical elective required courses required for all CHE students.

The overall program is then evaluated by the faculty at the end of each year. The yearly frequency is motivated by the fact that each outcome may not be equally covered in each quarter. The initial evaluation is performed by the ABET subcommittee with overall findings presented at the faculty retreat. The CEE ABET Committee evaluates whether each outcome was sufficiently met, and identifies deficiencies based on quantitative course assessments. Additionally, the committee reviews the senior exit surveys, the junior surveys (new for 2006), employer surveys, industry/graduate advisor surveys, and alumni surveys. The findings are documented and reported back to the faculty at the faculty retreat as a major agenda item. As the first complete annual data set (2004-2005) only recently became available, no major program actions (e.g., drastic curriculum or degree requirements changes) have been taken as a direct result of these findings. It is expected that as several years of data become available, a more precise assessment of trends can be performed and major changes, if required, will be implemented.

A recurrent challenge in assessing the degree to which outcomes 1-11 are achieved by our graduates has been the relatively low number of graduates (typically fewer than 20 each year) associated with a low response rate to our surveys. Thus, currently, the alumni and employer surveys do not have sufficient statistics to reliably evaluate and make program changes at the program outcome level. The alumni survey and employer survey are used primarily to evaluate program educational objectives and are discussed in detail in Section B.2.5. The alumni survey was also used to evaluate alumni support for program evaluation outcomes (as discussed later in this section).

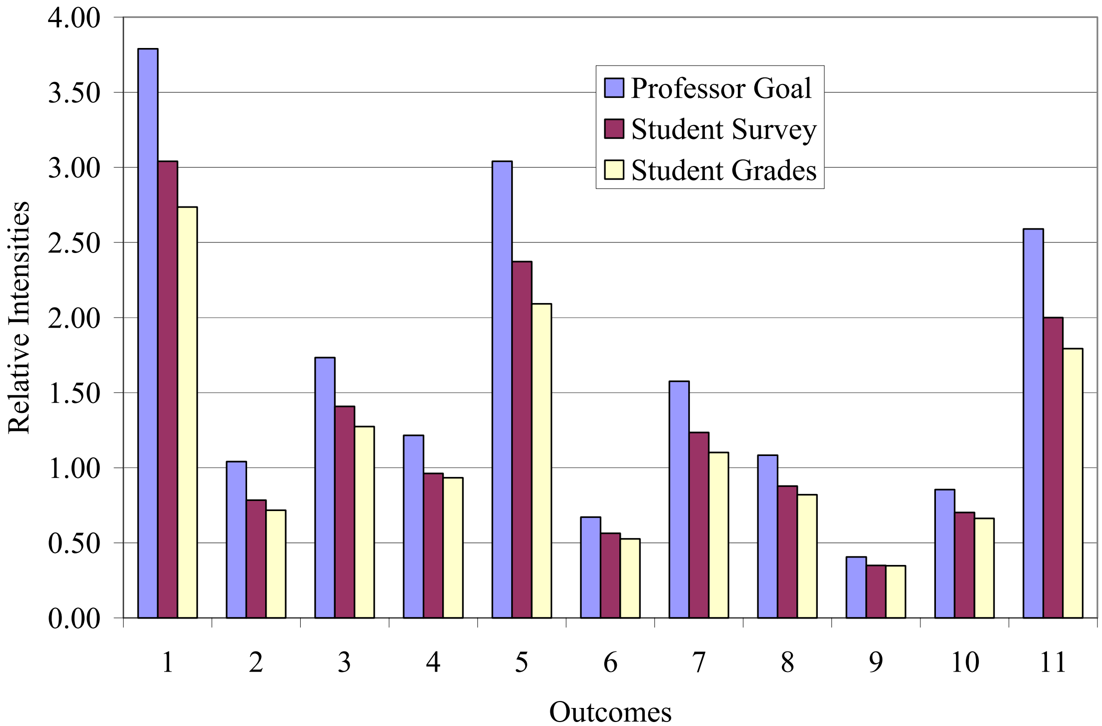


Figure 12. Example of a 2004 assessment of 1-11 (i.e., a-k) ABET outcomes. The Professor Goal represents the maximum achievable for the given outcome, the Student Evaluations are from the students surveys of the attainment of the course objectives (linked to ABET outcomes), while the Students Grades represent the degree to which students have reached ABET outcomes from a detailed evaluation of the students grades (linked to ABET outcomes). For more details on the assessment procedure and assessment, see Section B.3.3.

The senior exit surveys[1] and alumni surveys provide student feedback on the overall CHE program level on several different timescales. Clearly, students polled in the senior exit study are reflecting on the program completed over the preceding 4 years. A 1-4 year time lag in program changes is built into these results, depending on the class level when the change was implemented. For example, the 2002 change to add the freshman CEE 10/11 course would not be accurately reflected until the 2006 exit survey, whereas adjustments to CEE 158 in 2004 (senior level course) should be reflected in the 2005 exit survey. The alumni survey provides feedback over the duration of the CHE program with only a fraction of those surveyed having completed the CHE program with the most recent changes. However, the alumni survey provides additional feedback from students having had multiple years of experience after completion of the CHE major.

[1] We have experimented with different means of administering the senior exit survey. We now administer it through the Office of Student Academic Affairs. Students must complete the exit survey whey they file their applications for graduation. Graduation applications are not accepted without the survey. This assures 100% participation in the survey.

Every course in Chemical Engineering lists a set of course objectives that are designed to ensure that students completing the class will have the knowledge and skills to perform a specific set of tasks related to course content. Figure 13 provides an example of this set of objectives, for CHE 117 Separation Processes. The figure shows that the objectives are linked to program outcomes using a number on a scale of 0 to 3 to denote the strength of the relationships. The numerical system is based on an idea presented by Fiedler and Brent in the article "Designing and Teaching Courses to Satisfy the ABET Engineering Criteria (*Journal of Engineering Education*, January 2003). We have adapted it significantly.

Obj.	OUTCOME-RELATED LEARNING OBJECTIVES	OUTCOMES 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Broad overview of industrial separation processes. Understand their mechanisms and principles.	3		2		1	2		3		2	2			
2	Know how to apply numerical and graphical techniques to analyze separation processes in terms of equilibrium stage.	3	1	2		3					2				
3	Know how to use basic thermodynamic laws for phase equilibrium, and mass transfer concepts for the design of separation processes.	3		1		3			1						
4	Acquire basic skills that enable sizing of absorbers, distillation towers, dryers, and liquid-liquid extraction units	3		3		3			3	2	2				
5	Know how to use literature (correlations, graphs, vendor information etc.) to estimate the necessary parameter for dimensioning.	2	1	1		2		1	3						
6	To practice problem solving skills (homework, sample problems)	3	1	1	3	3		2			1	1			
7	Acquire basic knowledge of equipment used in chemical process separations	1		1		1									
8	Learn how to use a commercial computer aided design software (SuperPro Designer) for unit operation design, and understand basic theory "behind the code"	1	1	3	1	3	1		3	2	3	3			
	SUBTOTALS	19	4	14	4	19	3	3	13	4	10	6	0	0	0

Figure 13. Example of Course Objective Matrix: Fall 2005, CHE 117, Separation Processes.

When examinations or quizzes are set, the faculty member assigns a set of numbers to each one of the problems to link the relevance of the problem to each of the course objectives. This set of numbers is then scaled by the average of student scores for each problem to obtain measures of the degree of achieving course objectives. All faculty and lecturers are instructed on how the matrices should be completed so that a high degree of uniformity is ensured throughout the department.

The objective achievement scores are translated into corresponding outcome scores using the table described earlier. This procedure is used to assess achievement of program outcomes and ensures that faculty members and teaching assistants are constantly aware of program objectives and outcomes. The primary products of the procedure are 1) the relative weights assigned by the course to program objectives and outcomes, and 2) measures of the degree of achievement of the objectives and outcomes. At the end of each course, students also fill out surveys that provide subjective assessments of achieving course objectives and outcomes.

Next, a student evaluation of the course is calculated from an end of the quarter student survey. For this survey, the student is asked to score the degree to which he/she thinks the course objectives were achieved. The scores range from 1 through 3 (1=slightly achieved during class, 2=moderately achieved during class, 3=strongly achieved during class). The student surveys are collected with the scores for each objective averaged over all the students. This allows for a "weighting factor" to be calculated for each objective. For example, objective 1 weighting factor is calculated as (average student survey result for objective 1)/3 (where 3 is the theoretical maximum possible). The outcome factor in each column for objective 1 is then multiplied by the weighting factor to achieve an outcome student assessment score. All objectives are then summed for each outcome with the sum total providing the student assessment score. This value can be calculated as a fraction of the theoretical maximum (all students believe all objectives in course fully achieved).

Figure 14 shows results of the student survey for CHE 117. The bottom of Figure 14 summarizes the average student response (on a scale of 0-3, totals divided by 3) on achieving course objectives. Figure 15 takes the average student response on course objectives from Figure 14 and multiplies them with the outcome correlation coefficients from Figure 13 to result in a student achievement score on the 11 outcomes, as represented by the different course objectives. The subtotals in the bottom Figure 15 reflect the total outcome score, which can be divided by the maximum possible outcome score from Figure 13 to obtain the outcome student assessment score (e.g., 16.1/19 for outcome 1 = 84.6%). It was determined through a series of ABET Committee meetings that a value of 70% would constitute an action item to be addressed within the course assessment. A value below 70% for overall program outcome assessment would indicate an overall programmatic action item.

	Course Objectives							
Student	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	3	3	3	3	3	3	3	2
2	3	3	2	3	2	1	3	2
3	2.5	2.5	2	2.5	2	2.5	3	2.5
4	2	2	2	3	2	1	3	2
5	3	3	2	3	3	3	3	2
6	3	3	2	3	2	3	3	2
7	2	3	3	2	2	3	3	3
8	3	3	1	2	2	2	3	3
9	3	3	2	3	3	3	1	2
10	3	3	2	3	3	2	2	3
Average	0.92	0.95	0.70	0.92	0.80	0.78	0.90	0.78

Figure 14. End-of-class student survey response (10 students responded) for CHE 117 (Fall 2005).

	Outcomes										
Objective	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	2.8	0.0	1.8	0.0	0.9	1.8	0.0	2.8	0.0	1.8	1.8
2	2.9	1.0	1.9	0.0	2.9	0.0	0.0	0.0	0.0	1.9	0.0
3	2.1	0.0	0.7	0.0	2.1	0.0	0.0	0.7	0.0	0.0	0.0
4	2.8	0.0	2.8	0.0	2.8	0.0	0.0	2.8	1.8	1.8	0.0
5	1.6	0.8	0.8	0.0	1.6	0.0	0.8	2.4	0.0	0.0	0.0
6	2.4	0.8	0.8	2.4	2.4	0.0	1.6	0.0	0.0	0.8	0.8
7	0.9	0.0	0.9	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
8	0.8	0.8	2.4	0.8	2.4	0.8	0.0	2.4	1.6	2.4	2.4
9											
10											
Subtotals	**16.1**	**3.3**	**12.0**	**3.1**	**15.8**	**2.6**	**2.4**	**11.0**	**3.4**	**8.7**	**5.0**
Percent	**84.6%**	**82.9%**	**85.8%**	**78.3%**	**83.2%**	**87.2%**	**78.9%**	**84.2%**	**85.0%**	**87.0%**	**82.8%**

Figure 15. Outcome evaluation of student end-of-class survey, CHE 117 (Fall 2005).

Finally, an evaluation of student performance based on student grades is performed. Here, the instructor identifies the course specific objectives tested for each midterm and final problem (plus design project). Average student grades for each problem are then computed. The average student score on each problem is then input into each objective covered by the problem. The high score on each objective (fraction of 1) is then multiplied by the outcome values for that objective. Outcomes are then summed across objectives to obtain a component grade-based outcome score. The highest score for each objective is selected so that improvements in the objective over the course can be assessed as the final knowledge, not the intermediate knowledge, and thus outcome achievement is to be measured. Figures 16 to 19 provide an example of this evaluation process. Figure 16 is a linkage of quiz (qz1 to qz4), midterms (mt1_1 to mt2_2), homework, design project (des), and final (f1-f6) to course objectives. Average grades for each problem are then computed in Figure 17.

Objectives (a 1 in the matrix indicates problem addresses that objective)

Problem	1	2	3	4	5	6	7	8
mt1_1	1	1	1	1	0	0	0	0
mt1_2	1	1	1	1	0	0	0	0
mt1_3	1	0	0	1	0	0	1	0
mt1_4	1	1	1	1	0	0	0	0
mt1_5	1	0	1	1	0	1	0	0
mt2_1	1	0	0	1	0	0	0	0
mt2_2	1	0	0	1	1	0	0	0
mt2_3	1	1	1	1	0	0	0	0
mt2_4	1	1	1	1	0	0	0	0
mt2_5	1	1	1	1	0	0	0	0
spro	1	0	0	1	1	0	1	1
hw	1	1	1	1	1	1	0	0
f1	1	1	0	1	0	1	0	0
f2	1	1	0	1	0	1	1	0
f3	1	1	0	1	0	1	0	0
f4	0	1	0	1	1	1	0	0
f5	1	1	0	1	0	1	1	0
f6	1	1	0	1	0	1	1	0
f7	1	0	1	1	1	1	0	0
f8	1	1	0	1	0	1	0	0

mt1 = first mid term
mt2 = second mid term
spro = superpro computer exercises
hw = homework
f = final
indices represent problems in the exam
(e.g., final3 = 3rd problem in final exam)

Figure 16. Linkage of course questions to course objectives, CHE 117 (Fall 2005).

	Student (grade of each 11 students on all 20 problems)											
Problem	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Average**
mt1_1	3.0	10.0	5.0	5.0	10.0	3.0	5.0	5.0	5.0	0.0	6.0	51.8%
mt1_2	7.0	3.0	2.5	4.0	4.0	7.0	10.0	3.0	3.0	2.0	4.0	45.0%
mt1_3	10.0	8.0	6.0	10.0	10.0	10.0	8.0	8.0	8.0	10.0	8.0	87.3%
mt1_4	0.5	7.0	2.5	6.0	6.0	2.5	6.0	5.0	7.0	1.0	6.0	45.0%
mt1_5	6.0	10.0	10.0	10.0	7.7	8.3	6.0	10.0	8.7	8.3	9.0	85.5%
mt2_1	4.0	4.0	6.0	6.0	2.0	5.0	6.0	6.0	6.0	8.0	8.0	55.5%
mt2_2	2.0	7.0	8.5	8.5	9.0	7.5	8.0	8.5	6.0	8.0	8.5	74.1%
mt2_3	2.0	6.0	3.0	6.0	10.0	2.0	4.0	10.0	5.0	2.0	4.0	49.1%
mt2_4	5.0	10.0	7.0	9.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	60.0%
mt2_5	4.5	5.0	4.5	9.0	10.0	4.5	6.5	9.0	5.0	6.0	7.0	64.5%
spro	8.8	7.8	7.3	8.0	8.3	7.5	7.3	4.0	7.8	7.3	8.3	74.5%
homework	3.2	8.4	9.9	8.7	8.8	8.1	8.4	6.9	7.8	9.1	7.4	78.8%
f1	2.0	4.0	2.0	3.0	4.0	2.0	4.0	10.0	3.0	2.0	4.0	36.4%
f2	3.0	10.0	6.0	3.0	6.0	3.0	4.0	3.0	3.0	2.0	3.0	41.8%
f3	5.0	3.0	5.0	4.0	3.0	1.0	3.0	10.0	4.0	3.0	6.0	42.7%
f4	0.0	4.0	7.0	6.0	8.0	6.0	4.0	8.0	6.0	9.0	5.0	57.3%
f5	2.0	9.0	5.0	6.0	9.0	2.0	5.0	4.0	5.0	3.0	6.0	50.9%
f6	7.0	8.0	7.0	3.5	8.0	7.0	8.0	8.5	6.5	8.0	8.5	72.7%
f7	4.5	4.0	7.5	9.0	4.5	4.0	10.0	7.5	7.5	8.5	4.0	64.5%
f8	5.0	8.5	7.5	6.0	9.0	7.0	5.0	10.0	8.0	6.5	6.5	71.8%

Figure 17. Computation of average student score for each course problem.

	Course Objectives							
Problem	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
mt1_1	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
mt1_2	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
mt1_3	0.9	0.0	0.0	0.9	0.0	0.0	0.9	0.0
mt1_4	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
mt1_5	0.9	0.0	0.9	0.9	0.0	0.9	0.0	0.0
mt2_1	0.6	0.0	0.0	0.6	0.0	0.0	0.0	0.0
mt2_2	0.7	0.0	0.0	0.7	0.7	0.0	0.0	0.0
mt2_3	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0
mt2_4	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0
mt2_5	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0
spro	0.7	0.0	0.0	0.7	0.7	0.0	0.7	0.7
homework	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0
f1	0.4	0.4	0.0	0.4	0.0	0.4	0.0	0.0
f2	0.4	0.4	0.0	0.4	0.0	0.4	0.4	0.0
f3	0.4	0.4	0.0	0.4	0.0	0.4	0.0	0.0
f4	0.0	0.6	0.0	0.6	0.6	0.6	0.0	0.0
f5	0.5	0.5	0.0	0.5	0.0	0.5	0.5	0.0
f6	0.7	0.7	0.0	0.7	0.0	0.7	0.7	0.0
f7	0.6	0.0	0.6	0.6	0.6	0.6	0.0	0.0
f8	0.7	0.7	0.0	0.7	0.0	0.7	0.0	0.0
Subtotals	0.9	0.8	0.9	0.9	0.8	0.9	0.9	0.7

Figure 18. Association of student scores with course objectives.

	Outcomes										
Objective	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	2.6	0.0	1.7	0.0	0.9	1.7	0.0	2.6	0.0	1.7	1.7
2	2.4	0.8	1.6	0.0	2.4	0.0	0.0	0.0	0.0	1.6	0.0
3	2.6	0.0	0.9	0.0	2.6	0.0	0.0	0.9	0.0	0.0	0.0
4	2.6	0.0	2.6	0.0	2.6	0.0	0.0	2.6	1.7	1.7	0.0
5	1.6	0.8	0.8	0.0	1.6	0.0	0.8	2.4	0.0	0.0	0.0
6	2.6	0.9	0.9	2.6	2.6	0.0	1.7	0.0	0.0	0.9	0.9
7	0.9	0.0	0.9	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
8	0.7	0.7	2.2	0.7	2.2	0.7	0.0	2.2	1.5	2.2	2.2

Figure 19. Association of course objective scores (based on student grades) to ABET outcomes.

Figure 18 then links the average student score for each problem to an objective score per Figure 16. The subtotals in Figure 18 for each objective are then multiplied by the outcome score for each objective (Figure 13) to obtain the final grade based outcome scores subtotaled in Figure 19. Lengthy discussions amongst the ABET Committee determined that a grade based outcome score below 70% should be addressed in the course assessment and addressed the next offering of the course.

In summary, the assessment process results in:

- Relative weights assigned to outcomes by each course in the CHE program.
- Component grade based measures of degree of achievement of course objectives and outcomes.
- Survey based measures of degree of achievement of course objectives and outcomes.
- Comments from students on course deficiencies and possible improvements in course (university administered teaching evaluations)

This information is used by faculty members and instructors to improve the course. Faculty members also rely on formal teaching evaluations conducted by the University. The overall outcome files for the entire program are also assessed to ensure proper coverage and attainment of all 11 desired program outcomes and CHE program goals.

To ensure that the information generated by the assessment procedures is used to modify courses to achieve program objectives and outcomes, faculty members are asked to make specific suggestions, which are included discussed collectively at faculty meetings and become part of each course file. The instructor who teaches the course the next time is then asked to respond to these suggestions in writing, and relate improvements to these suggestions if possible. Faculty members are required to comment on and make suggestions for improvement for any outcome score (student survey or student grade based) below 70%. An example of the course assessment and adjustments made are found in Section B.3.4.

Overall Program Outcome Assessment

Because every course results in relative weights and achievement scores for the same set of program outcomes, the course statistics can be combined to provide a composite picture of the entire program, which can be then related to the CHE program objectives. The program as a whole is also assessed in terms of achieving program outcomes by conducting a survey of senior students during the senior design course. Several questions in this survey are directly related to program outcomes.

This subsection discusses how each of the outcomes are addressed in the CHE undergraduate program. Table 5 summarizes the 2004-2005 academic year percent weighting for each outcome for each required course within the engineering program with the exception of CS 10 (unavailable).

Figure 20 shows the relative distribution of outcome coverage for the overall CHE program for the 2004–2005 academic year. The relative outcome distribution is derived from the core curriculum classes for CHE majors including ENGR 118. Each class is normalized by their total outcome score (sum of professor goals for all 11 outcomes) to ensure equivalent weighting of courses (to prevent courses with more course objectives being weighted unequally). The relative outcome score is then calculated by summing the normalized weightings for each course and dividing by the number of outcomes. This formula would result in a relative weighting score of 1.0 for all outcomes if they were covered identically. It was determined by the ABET Committee that the ideal relative outcome score for each outcome should be between 0.4 and 2.0, in order to be reasonably well represented. To simplify the departmental analyses, the following percentages with respect to outcome weightings do not reflect the technical electives that differentiate the bioengineering chemical and biochemical engineering options from one another. Analysis with and without these three courses does not significantly impact on the overall weighting for each outcome. Very little programmatic variability in the percent weighting for outcomes was seen between 2004-2005 and 2005-2006 except for CEE158 and ENGR 118 (see notes for outcome 6 and 9 coverage below).

Table 5. Percent weighting for each outcome for each course in CHE program.

Outcomes--->	1	2	3	4	5	6	7	8	9	10	11
Required Chemical Engineering Courses											
CHE 116	27.8	7.2	13.4	1.0	26.8	2.1	3.1	2.1	2.1	1.0	13.4
CEE 10/11	11.1	1.4	2.8	2.8	0.0	16.7	9.7	13.9	15.3	15.3	11.1
CEE 130	39.2	2.7	4.1	0.0	24.3	0.0	13.5	2.7	0.0	0.0	13.5
CEE 158	14.6	4.5	0.0	4.5	15.7	9.0	3.4	21.3	4.5	9.0	13.5
CHE 100	39.5	0.0	7.9	7.9	10.5	2.6	13.2	5.3	2.6	5.3	5.3
CHE 114	23.9	4.3	18.5	1.1	22.8	2.2	3.3	3.3	0.0	3.3	17.4
CHE 120	32.3	4.8	8.1	3.2	25.8	0.0	3.2	3.2	1.6	0.0	17.7
CHE/ENVE 160A	11.1	8.3	8.3	18.5	11.1	0.9	16.7	4.6	0.0	4.6	15.7
CHE/ENVE 175A	14.3	5.0	10.9	16.0	10.9	7.6	5.9	7.6	3.4	5.0	13.4
CHE/ENVE 175B	14.4	4.2	11.0	16.1	11.0	7.6	5.9	7.6	3.4	5.1	13.6
CHE/ENVE 160B	10.0	9.0	8.0	17.0	10.0	1.0	18.0	5.0	0.0	5.0	17.0
CHE110A	22.5	8.5	8.5	0.0	16.9	2.8	16.9	2.8	0.0	4.2	16.9
CHE110B	23.3	3.3	20.0	1.7	21.7	3.3	5.0	0.0	0.0	0.0	21.7
CHE117	19.2	4.0	14.1	4.0	19.2	3.0	3.0	13.1	4.0	10.1	6.1
CHE118	20.9	4.7	11.6	0.8	23.3	2.3	2.3	7.0	0.0	10.1	17.1
CHE122	29.6	12.3	13.6	0.0	25.9	3.7	3.7	0.0	3.7	0.0	7.4
CHE160C	11.1	8.3	8.3	18.5	11.1	0.9	16.7	4.6	0.0	4.6	15.7
CS 10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ENGR 118	14.1	11.3	4.2	8.5	16.9	1.4	14.1	4.2	0.0	2.8	22.5
BioChem Option											
CHE124	34.0	11.3	17.0	1.9	28.3	0.0	3.8	0.0	3.8	0.0	0.0
CHE 124L	34.1	34.1	0.0	22.7	0.0	0.0	6.8	0.0	0.0	2.3	0.0
CEE 132	20.0	2.4	3.5	7.1	11.8	4.7	14.1	12.9	5.9	10.6	7.1
Chem Option											
CEE 125	9.6	32.7	0.0	9.6	0.0	0.0	17.3	5.8	3.8	21.2	0.0
ENVE 134	25.3	2.5	19.0	0.0	30.4	1.3	0.0	8.9	0.0	8.9	3.8
ENVE 133	17.0	5.4	8.8	2.0	10.9	3.4	3.4	14.3	4.8	18.4	11.6
ENVE 120	22.0	6.5	21.1	0.0	22.8	1.6	0.0	5.7	0.0	5.7	14.6
CHE 102	18.3	10.0	6.7	7.5	15.0	5.0	10.0	7.5	7.5	7.5	5.0
CEE 132	20.0	2.4	3.5	7.1	11.8	4.7	14.1	12.9	5.9	10.6	7.1
BioEng Option											
CHE124	34.0	11.3	17.0	1.9	28.3	0.0	3.8	0.0	3.8	0.0	0.0

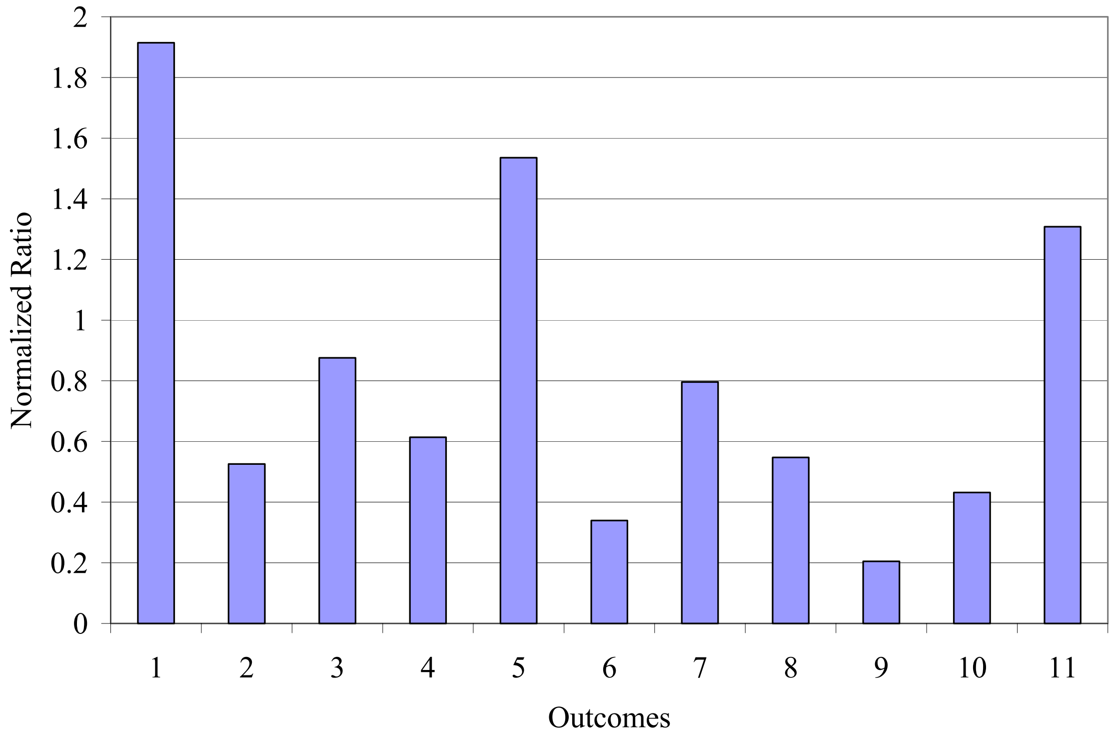


Figure 20. Relative distribution of outcomes 1-11 for the overall CHE program for the 2004 –2005 academic year.

The ABET Committee was pleased with the 04-05 distribution of outcome weightings for a first program-wide attempt. As expected, key outcomes in engineering curricula (outcomes 1, 5, 11) scored well above 1.0. It was noted by the ABET Committee that the outcome scores fell within the predefined expectation of weightings with the exception of outcomes 6 and 9. Discussion of this issue among CEE faculty identified the fact that these outcomes were indeed covered in the courses, but that most likely, they had a low coverage in the course objectives. Therefore, it was brought to the attention of the faculty that any course that could cover outcome 6 and 9 in more depth should consider increasing their coverage and representation of these two outcomes through additional or modified course objectives. It was further determined that ENGR 118 (to be taught inside the CEE department for the first time) and CEE 158 (professional development course) should increase their coverage of outcomes 6 and 9 for the 2005-2006 year. Figure 21 shows the 2005-2006 weightings for each outcome. The ABET Committee was pleased by the improvement in the outcome weightings for outcome 6 and outcome 9. However, to ensure that outcome 9 continues to increase in coverage, it was suggested to the faculty that each course (when possible) add a course objective that would emphasize lifelong learning (outcome 9). It was also noted by the committee that the courses covered by the committee all covered this objective fairly strongly in their courses and that the percent weightings in the matrix (due to lack of course objective specifically targeting this outcome) underrepresented actual coverage in the course. Therefore, it is expected that the 2006-2007 relative distribution will have greater emphasis on outcome 9. It was noted with respect to outcome 6 that a couple of courses focusing on professional engineering and ethics were outweighed by the number of courses covered by the major and that outcome 6 was likely addressed to a reasonable level in CEE 10/11, CEE 158 and the capstone senior design courses (CHE 175AB).

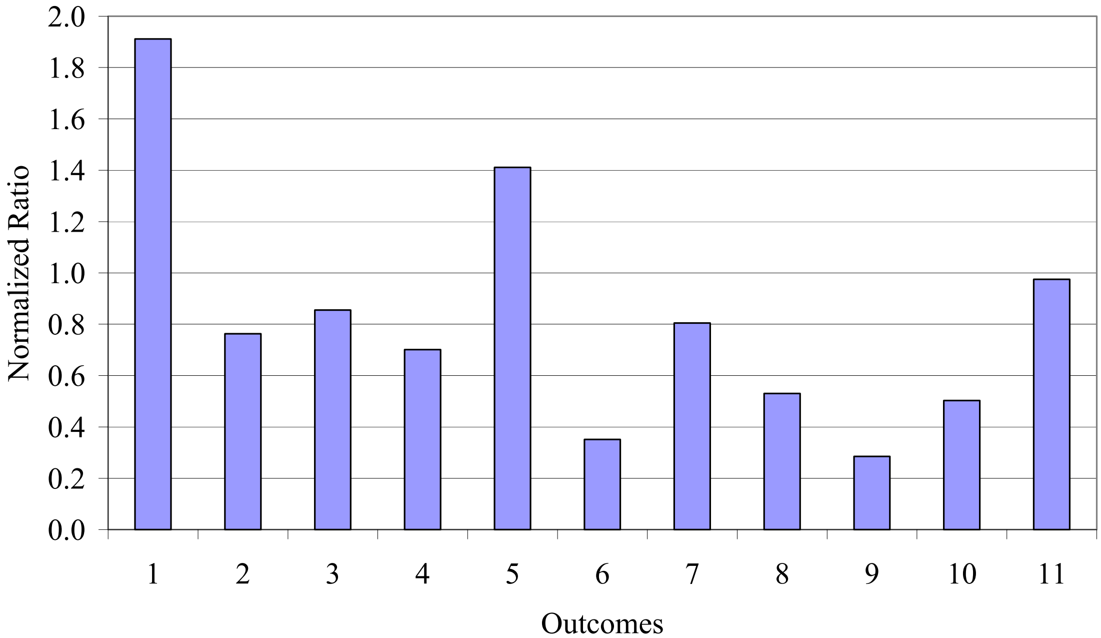


Figure 21. Relative distribution of outcomes 1-11 for the overall CHE program for the 2005 –2006 academic year.

Outcome 1: An ability to apply knowledge of mathematics, science and engineering
The majority of the CHE courses are designed to address this outcome, as reflected in Figures 20 and 21 and Table 5. In 2004-2005, the relative outcome weighting was 1.91 for this outcome. CHE 110A and 110B, Chemical Process Analysis, is the first course to emphasize the application of science and mathematics to engineering problems and is currently designed to be taught in the sophomore year (Fall and Winter). This is followed by CHE 122 (Chemical Engineering Kinetics), and later with Thermodynamics (CHE 100 and 130). All these courses have some of the highest weightings for outcome 1 throughout the curricula. A special emphasis on engineering mathematics is placed in ENGR 118 (Engineering Modeling and Analysis) a stringent 5-unit course. Many courses throughout the junior and senior year are heavily weighted toward outcome 1 providing evidence that outcome 1 is strongly represented throughout the curriculum.

Outcome 2: An ability to design and conduct experiments, as well as analyze and interpret data
Outcome 2 is addressed in part in a number of the CHE curriculum courses with a relative distribution score of 0.53. Several key courses present in the curriculum are significantly weighted toward this goal including the hallmark required laboratory courses series CHE 160ABC (Chemical Engineering Laboratories). Additional laboratory experience is acquired in CEE 125 (Analytical Methods for Chemical and Environmental Engineers), a technical elective for the chemical engineering option, or CHE 124L (Biochemical Engineering Laboratory) for the biochemical engineering option. Bioengineering option students take BIOL 5B and 5C, which both include a laboratory. CEE 125 focuses a significant portion of the class on experiment

design, ability to conduct experiments, and ability to interpret instrumental data. The first third of the class provides critical quantitative chemistry tools while the final two-thirds of the class focus on experimental design, instrumental analyses, and interpretation of the experimental results. Four of the five course objectives of CHE 124L start with "Design and conduct experiments and analyze data." CHE 124L laboratories are relatively open-ended. They give students an opportunity to think creatively, and apply their analytical skills developed throughout the curriculum towards a set objective. The senior design project (CHE 175AB) also requires students to independently design experiments and to analyze and interpret data. Only a few other courses have large weightings on this outcome, however a number of others courses do spend the equivalent of 1-2 lectures on data analyses and interpretation. Several courses require students to analyze and interpret data used by professionals in the field, e.g., equipment vendor information (pump curves, random packing characteristics, etc.), charts or tables, etc. This is usually done in homework, or term design projects.

Outcome 3: 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 and health, manufacturability, and sustainability

This is a relatively important outcome which was assigned a relative distribution score of 0.88 in 2004-05 in the CHE program. Design is emphasized in most courses including those offered in the junior year. In these classes, students work in teams to design a system or component to meet specifications, write a report, and make an oral presentation. Key CHE courses with significant weightings for outcome 3 include CHE 114 (Applied Fluid Mechanics), CHE 110B (Chemical Process Analysis), CHE 116 (Heat Transfer), CHE 122 (Kinetics), and CHE 117 (Separations Processes). Several electives also contain significant coverage of this outcome (e.g., CHE 124, ENVE 120 and 134). For example, in ENVE 120, students worked in groups to design a water treatment system for a chemical spill of the student's choice as a result of Hurricane Katrina. The capstone design courses, CHE 175A and 175B, as well as CEE 158 (Professional Development for Engineers) pay special attention to ethical and health and safety concerns in design. Many courses, by virtue of being also listed as technical electives for environmental engineering students, stress environmental concerns. CHE 175 A and B also require consideration of economics, feasibility, and sustainability issues. Green engineering (CEE 132) a technical elective available for both chemical and biochemical engineering options, provides an opportunity for students to deepen their understanding in novel contemporary, novel manufacturability, and sustainability issues.

Outcome 4: An ability to function on multidisciplinary teams

The joint Chemical and Environmental Engineering department and overlap through a number of joint classes between ENVE and CHE students lead to many multidisciplinary team activities. Almost all courses have a design component or projects, requiring team members from both ENVE and CHE and from diverse backgrounds to function together to achieve project goals. Not surprisingly, the laboratory courses (CHE 160 series) and senior design project (CHE/ENVE 175AB) score the highest in this outcome. However, this aspect is also represented in course scoring low. For example, in CHE 114 (Applied Fluid Mechanics), a required course for both majors, the design teams are evenly integrated between majors. In CHE 120 (Mass Transfer, a course taken by both CHE and ENVE majors), team problem solving, with teams randomly chosen, is practiced in class. In key courses involving teamwork, students work in teams to prepare technical memoranda, technical reports, and oral presentations. A relative distribution score of 0.61 was found for outcome 4 in the 2004-2005 year.

Outcome 5: An ability to identify, formulate, and solve engineering problems

This important outcome, with a relative distribution score of 1.54 (second only to outcome 1), is emphasized in the majority of the courses in the CHE curriculum. This outcome is stressed throughout the sophomore, junior, and senior level courses. This outcome is first addressed in the sophomore year in Chemical Process Analysis (CHE 110A and 110B) and Kinetics (CHE 122) and then is built upon in nearly every course that follows through the junior and senior year. An important part of teaching and practicing problem solving is during discussions. Most CEE faculty hold their own discussions, rather than leaving them to the TAs. It is expected that the students will have mastered this outcome and thoroughly demonstrate it in the Senior Capstone Design Course.

Outcome 6: An understanding of professional and ethical responsibility

The introductory course in chemical and environmental engineering, CEE 10/11 (Introduction to Chemical, Environmental and Bioengineering), deals with professional and ethical responsibility in all activities related to being a student as well as a practicing engineer. These concepts are reinforced throughout the curriculum, and strongly reinforced in senior courses CEE 158 (Professional Development for Engineers) and in the design courses CHE 175A and 175B, which have several lectures devoted to safety, ethics and professional responsibility. Discussions among the faculty and constituents indicate that ethical responsibility, especially with respect to environmental concerns, is covered in a number of other courses (e.g., CHE 117 Separation Processes) although specific lectures on the topic are not necessarily provided. The CHE curriculum had a 0.34 relative distribution score toward this category in the 2004-2005 year. Changes to ENGR 118 and CEE 158 improved this distribution score for 2005-2006 (see Figure 21) and further improvements of the representation of this outcome are expected in the upcoming academic years.

Outcome 7: An ability to communicate effectively

Students are required to write design reports and make oral presentations in several courses. The importance of the ability to communicate effectively is stressed in the first course taken by our students (CEE 10/11) in their freshman year (two of the course objectives are directly related to communication). Presentation skills are taught and practiced in CEE 10/11 and emphasized throughout our curriculum (e.g., three presentation per students in elective CEE 132 constitute 40% of the grade). The capstone design course, CHE 175AB, emphasizes this outcome as do the laboratory courses CHE 160ABC, and CEE 125. Many other classes (required or electives) address this outcome through written and/or oral interim and final reports for individual/team design projects. The relative distribution score for outcome 7 is 0.80. Discussion with the Advisory Board in May 2006 stressed the importance of effective writing skills. CEE faculty will be monitoring the writing skills of senior students more closely in order to decide whether a technical writing course newly introduced in the College of Engineering should be made mandatory.

Outcome 8: The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

Lectures and discussions in CEE 10/11, CHE 117 (Separation Processes), CEE 158 (Professional Development for Engineers) and CHE 175AB (Senior Design) deal explicitly with this outcome. Other courses in which this outcome is covered include several technical electives, e.g., CEE 132 Green Engineering, CHE 171 Pollution Control for Chemical Engineers, or the ENVE courses listed as electives which deal explicitly with diverse issues related to the impact of air and water quality control engineering on local, regional and global contexts including economic and societal issues. The senior design project requires students to place their project in a global, economic, environmental, and societal context. Often, this is done as team work, and involves students from both CHE and ENVE majors. The relative distribution score of this outcome in the 2004-2005 curriculum is 0.55.

Outcome 9: Recognition of the need for and an ability to engage in lifelong learning

CEE 158 (Professional Development for Engineers) plays an important role in achieving a recognition of the need for lifelong learning, and has the highest weighting in this outcome. Other courses include this outcome, but do not necessarily measure it (see discussion of Figures 20 and 21). Most courses assign problems and design projects that require research and understanding of material not included in the syllabi. This promotes recognition of the need to engage in learning beyond the classroom material and lifelong learning. This outcome is also covered through extracurricular (required or recommended) activities. Quarterly individual meetings of students with their faculty advisers is one strong factor in stimulating students to recognize the need to engage in continuous learning. Another factor is the encouragement to participate in the student chapters of professional societies, to conduct research and to find internships. Interactions of students with our part-time lecturers will also stress the importance of lifelong learning to remain competitive on the job market. The relative distribution ratio for this outcome in the curriculum is about 0.20 for 2004-2005. This was increased for 2005-2006 through more lectures focused on course objectives weighting more heavily on Outcome 9 in ENGR 118 and CEE 158 and is currently being carefully watched by CEE faculty (see also Figure 21 and associated discussion).

Outcome 10: Knowledge of contemporary issues

Several courses assign problems and design projects that require students to be aware of contemporary issues. For example, CEE 10/11 discusses contemporary issues in chemical and environmental engineering during the freshman year to engage students in their major and increase student retention rates. Later, in CHE 117 (Separation Processes), selected articles from Chemical Engineering Progress are distributed to the students. The articles (e.g., “Separations Research Needs for the 21st Century”, “Get More Out of Single-Stage Distillation”) provide a contemporary outlook on the topics being taught, and force students to acknowledge the existence of alternative approaches to the problems being solved in the course. Another example is ENVE 133 (an elective for the chemical engineering option), which includes several group discussions on the causes and impacts of global climate change, and current state of knowledge of health effects from key atmospheric pollutants. Professors for each class incorporate their own research programs into course material to ensure discussion and knowledge of contemporary issues. CEE 125 is designed for students to use experimental design and instrumentation and apply them to current issues such as water quality. Students are also encouraged to participate in extracurricular activities such as seminars, research internships, conferences, etc. which will increase their awareness of contemporary issues. Finally, several of our part-time lecturers work full-time in industry or in consulting businesses. They bring a different perspective in the classroom, often blending their professional and contemporary experience with textbook materials. The relative weight distribution ratio for 2004-2005 was 0.43.

Outcome 11: Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

This important outcome, with a relative distribution ratio of 1.31, is taught in several key courses and reinforced and almost all required and elective engineering courses. Modern engineering requires an appreciation of modeling, software tools, and experimental techniques. Freshmen are introduced to advanced features (e.g., solver, statistics modules) of MS Excel. ENGR 118 provides intensive instruction on advanced numerical techniques necessary for engineering practice and on modeling (e.g., using MATLAB). The knowledge and skills acquired in these classes are reinforced and applied in subsequent classes, for example in homework, student projects, and most importantly during the laboratory classes (CHE 160ABC) and the senior design project (CHE 175AB series). Other examples of modern engineering tools include using computer data acquisition in the CHE 160ABC series, the introduction of the computer aided design software SuperPro Designer in CHE 117 (Separation Processes) and frequent use of that software for senior design. Research activities, either extracurricular or through CHE 190 Special Studies, provide one more opportunity to acquire advanced skills in modern engineering tools.

B.3.4 Evaluation of Program Outcomes

As discussed in section B.3.3, each course has an outcome matrix. Additionally, for each course, student evaluations of how well each course met their objectives as well as a student grade based evaluation of performance are calculated (see Section B.3.3 for a description of the methodology). A further assessment of the program outcomes is conducted during the final presentation of the senior design projects.

A summary of student performance for each outcome measured across the CHE program for all required courses (CHE, CEE courses only) with the exception of the technical electives (to allow for simpler identification of student outcomes) is provided in Figures 22 and 23. These scores are weighted evenly across all core curricula to ensure that a single class does not have large bias or is underrepresented in the calculation. Then the student outcomes for the three technical electives within the water and air option are briefly discussed at the end of this section. ME 10, ENGR 118, and CS 10 were excluded from this calculation since the CHE student body is such a minor fraction of the overall student body in those three courses that average student performance in these courses would not be a reflection on outcome achievement for CHE students.

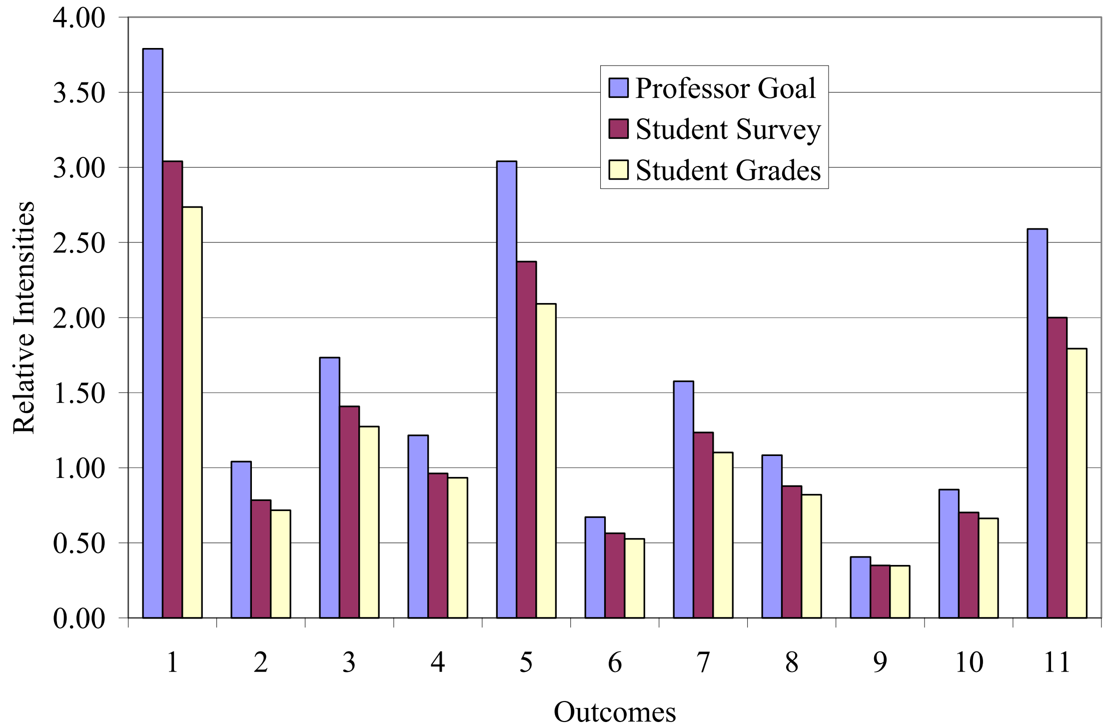


Figure 22. 2004-05 outcome assessment for CHE program required courses, absolute scale.

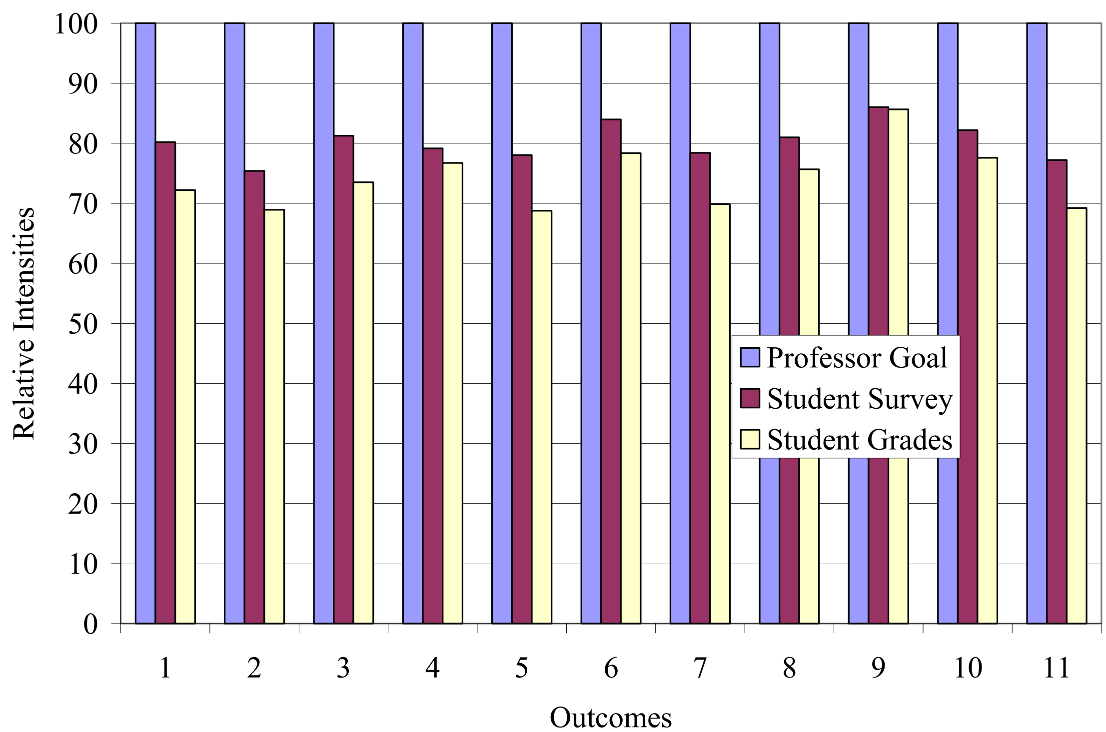


Figure 23. 2004-05 outcome assessment for CHE required courses as a percent of ideal scores.

A threshold for action on any outcome was set through a number of meetings of the ABET Committee at 70%. It was further decided that this would serve as an initial basis until a sufficient number of years of data could be evaluated on a trends basis. We expect that we will need a minimum of three to four years of data in our new evaluation matrix format before a trends analyses can be performed. However an absolute assessment can be made. The review of the 2004-2005 summary outcome file indicated the following:

- Students, through end of quarter surveys, believed that all 11 outcomes were suitably covered within the course curriculum with the lowest score of 75% for outcome 2 (An ability to design and conduct experiments, as well as analyze and interpret data). Nearly all outcomes, averaged throughout the program, were close to the 80% mark. The faculty were generally satisfied that the students bought into the objectives/outcomes for the curriculum but noted that continued monitoring was necessary given that the data represented a one year snapshot.
- Student grades tended to be lower than their perceived subject knowledge. While the students assessed their knowledge of the outcomes at 80%, their grades reflected a score of 74%. The faculty was encouraged that the discrepancy between student evaluation and student grades was relatively small.
- It was noted that a majority of outcomes met the minimum student grade threshold of 70%. However, student grades for outcomes 2, 5, and 11 were below, but close to our threshold score and warranted a close look over the upcoming year. Since these scores were close to the minimum threshold and the results only reflected one student group, it was decided that no major programmatic changes were warranted at this time. It was brought to the faculty's attention that outcomes 2, 5, and 11 were the lowest scoring and warranted an especially close look during the 2005-2006 campaign. Some examples of individual class changes based on this summary result are provided in Section B.3.6.
- Student grades on outcome 7 should also be tracked closely. Faculty were asked to address the objectives within these courses leading to these outcomes as deemed appropriate by each individual course instructor.

Student grade for outcome 9 (86%) was exceptionally high, indicating especially strong performance/coverage on the recognition for the need of lifelong learning.

Scores on technical electives courses generally reflected those of the CHE core classes with some differences specific to the selected option. Figures 24 through 29 summarize performance on CHE technical electives for biochemical engineering option (Figures 24 and 25), chemical engineering option (Figures 26 and 27), and bioengineering option (Figures 28 and 29). Coverage of outcomes for the technical electives for both biochemical and chemical engineering options are very similar to the core required courses for the major, with higher achievement scores in the technical electives (many scores markedly above the 80% mark). Coverage of outcomes by the technical electives of the bioengineering option is uneven and scores have a high standard deviation. This is most probably dues to the low number of CEE courses (i.e., course evaluated by our assessment method) represented in the technical electives for that option. This is not a point of great concern to CEE faculty, as outcomes were deemed to be well covered and good success in achieving the outcomes was observed, as shown earlier in Figure 22 and 23.

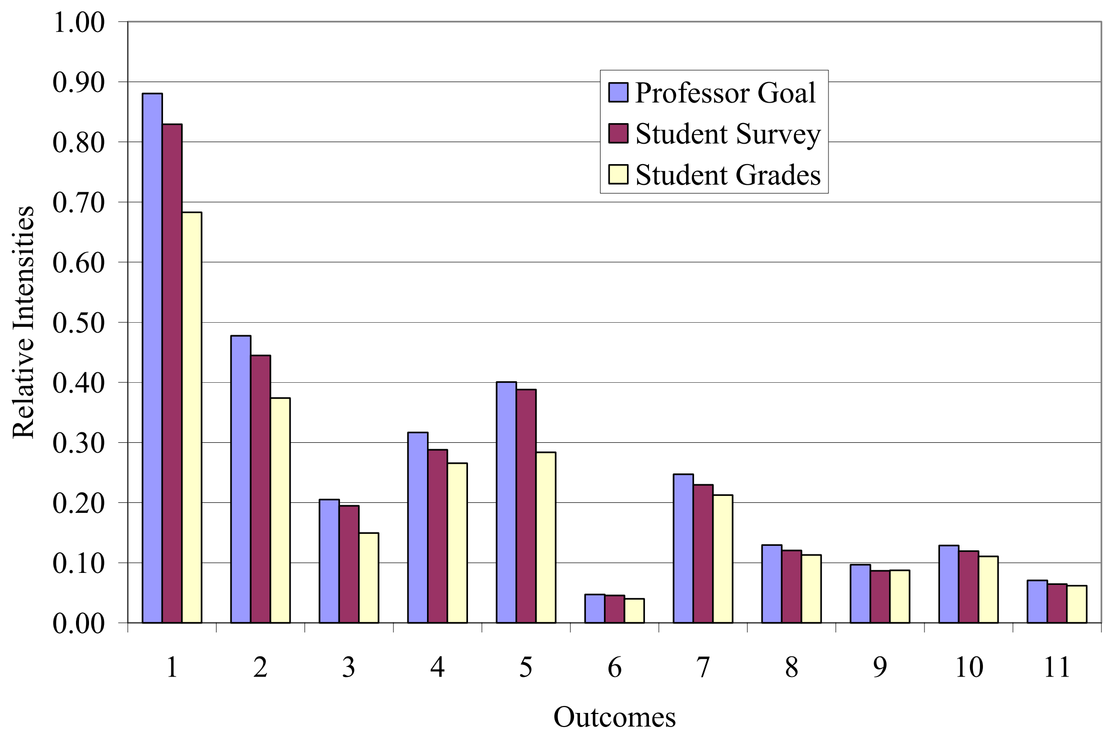


Figure 24. 2004-05 outcome assessment for the technical electives in the biochemical engineering option, absolute scale.

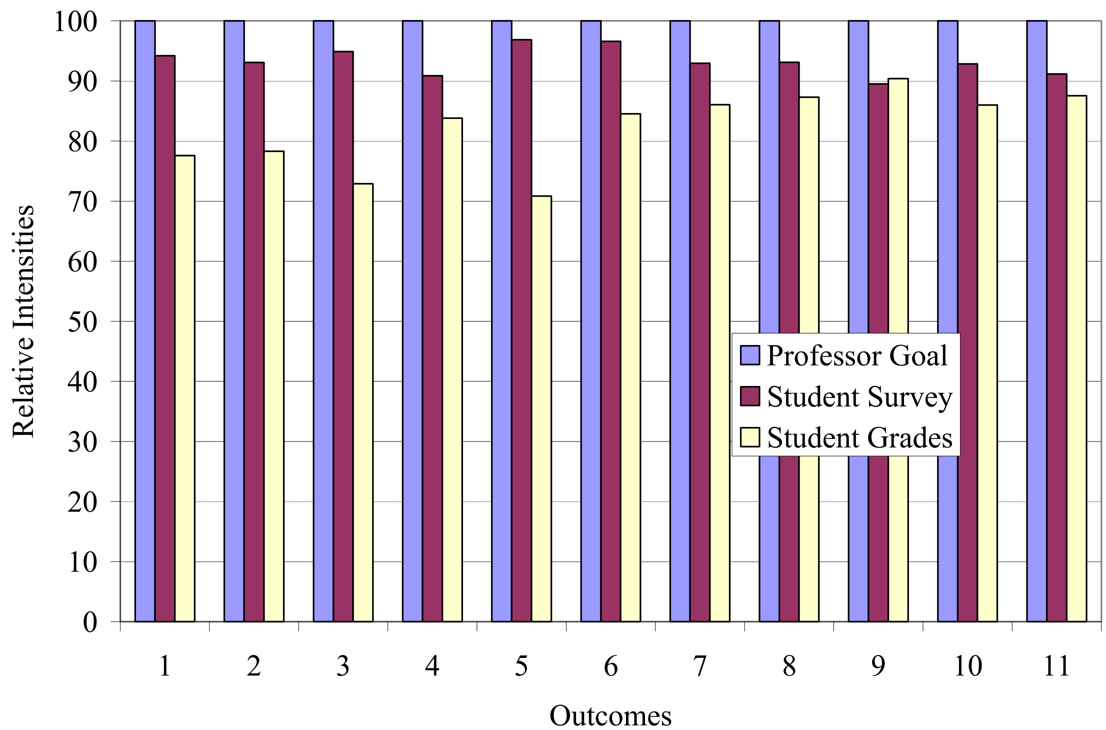


Figure 25. 2004-05 outcome assessment for the technical electives in the biochemical engineering option, as a percent of ideal scores.

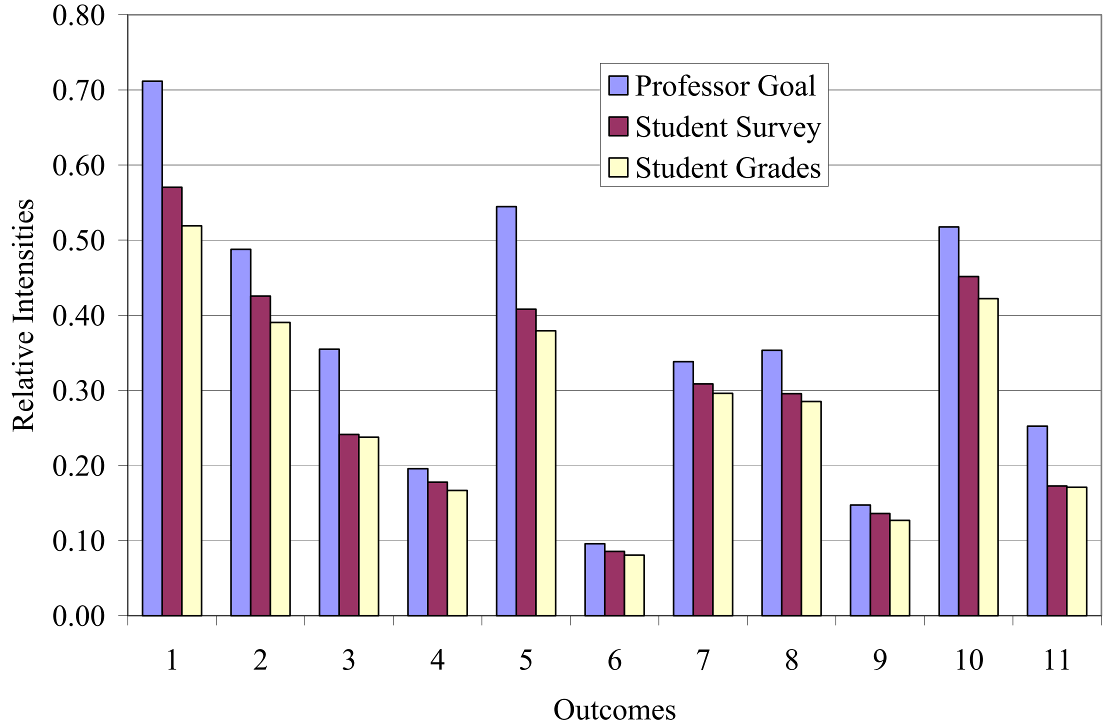


Figure 26. 2004-05 outcome assessment for the technical electives in the chemical engineering option, absolute scale.

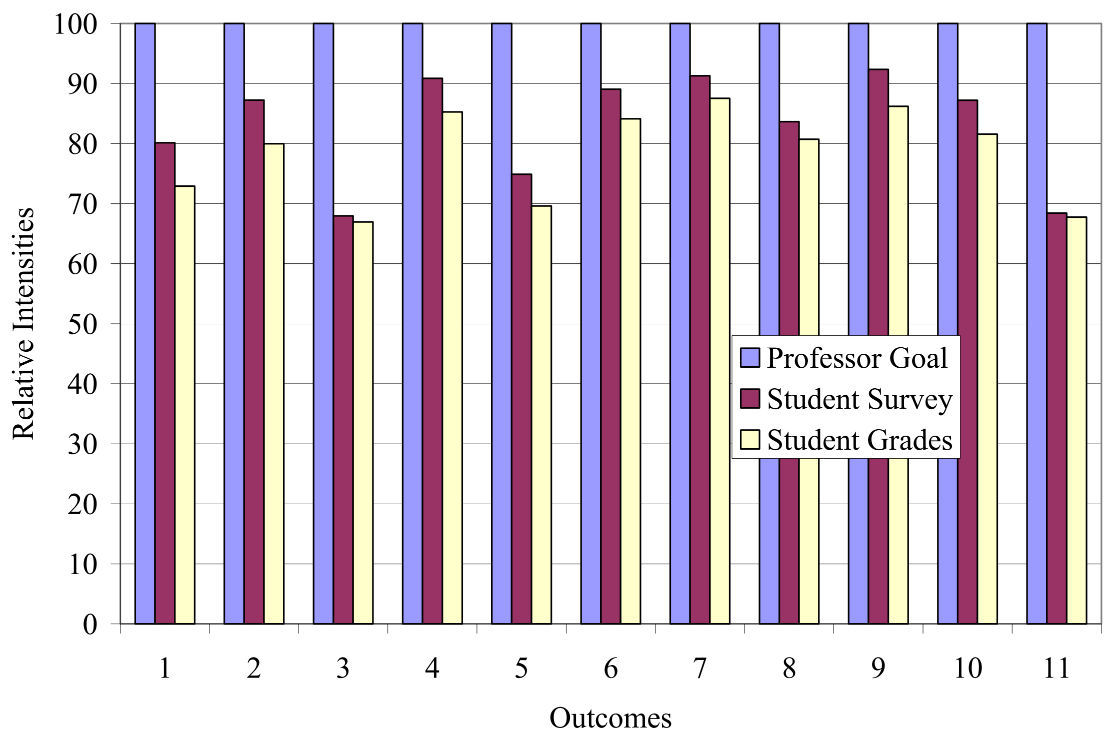


Figure 27. 2004-05 outcome assessment for the technical electives in the chemical engineering option, as a percent of ideal scores.

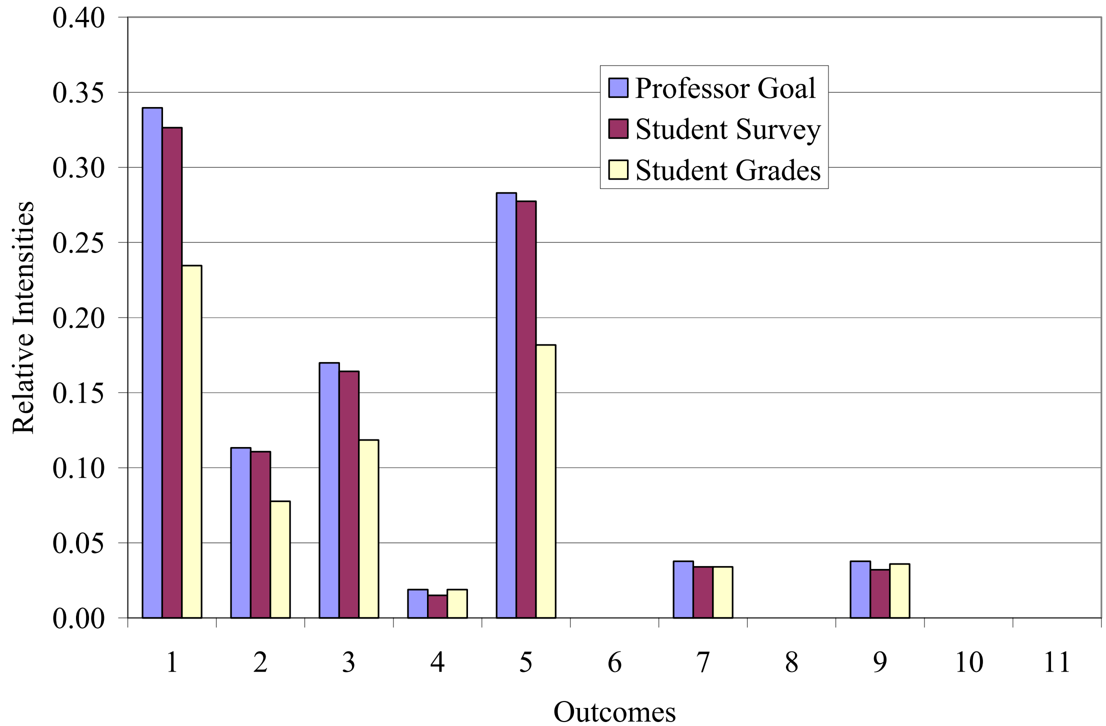


Figure 28. 2004-05 outcome assessment for the technical electives in the bioengineering option, absolute scale.

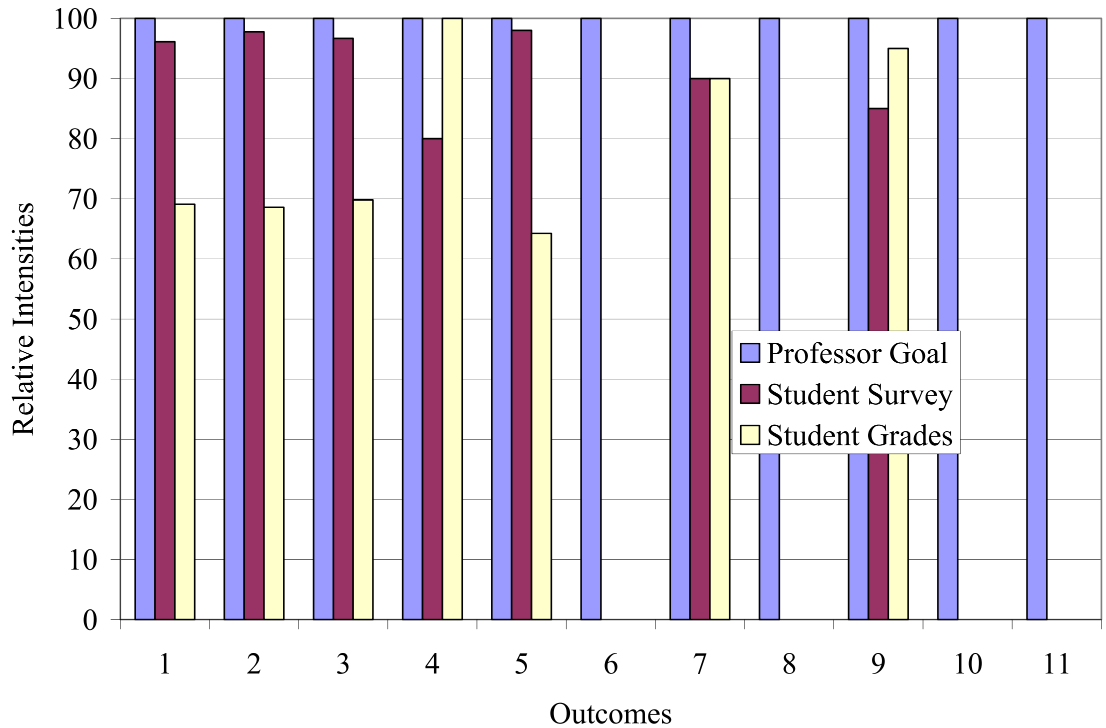


Figure 29. 2004-05 outcome assessment for the technical electives in the bioengineering option, as a percent of ideal scores.

Additionally, instructor evaluations provide a key feedback mechanism between the students and instructors. These surveys provide student feedback on the quality of the instruction and also leave an open comments section for feedback to the instructors, which can be incorporated into the following years courses. Given that these forms are centralized through the university and take approximately 10 weeks, feedback from this loop occurs after the course assessment is completed and is therefore not formally included in the course assessment but is taken seriously by the faculty. In addition, this feedback is often focused on the individual instructor requiring changes in instruction style, which is not course specific.

The alumni survey was also used to evaluate how well our alumni believe that the CHE program is addressing each of the program outcomes. These results must be interpreted cautiously in light of the small number of alumni responses and also the timescale of the alumni response to program changes made after student graduation. Figures 30 and 31 summarize the alumni response to the 11 outcomes. Possible scores range from a 5 (highest) to a 1 (lowest). Table 6 summarizes the outcome averages.

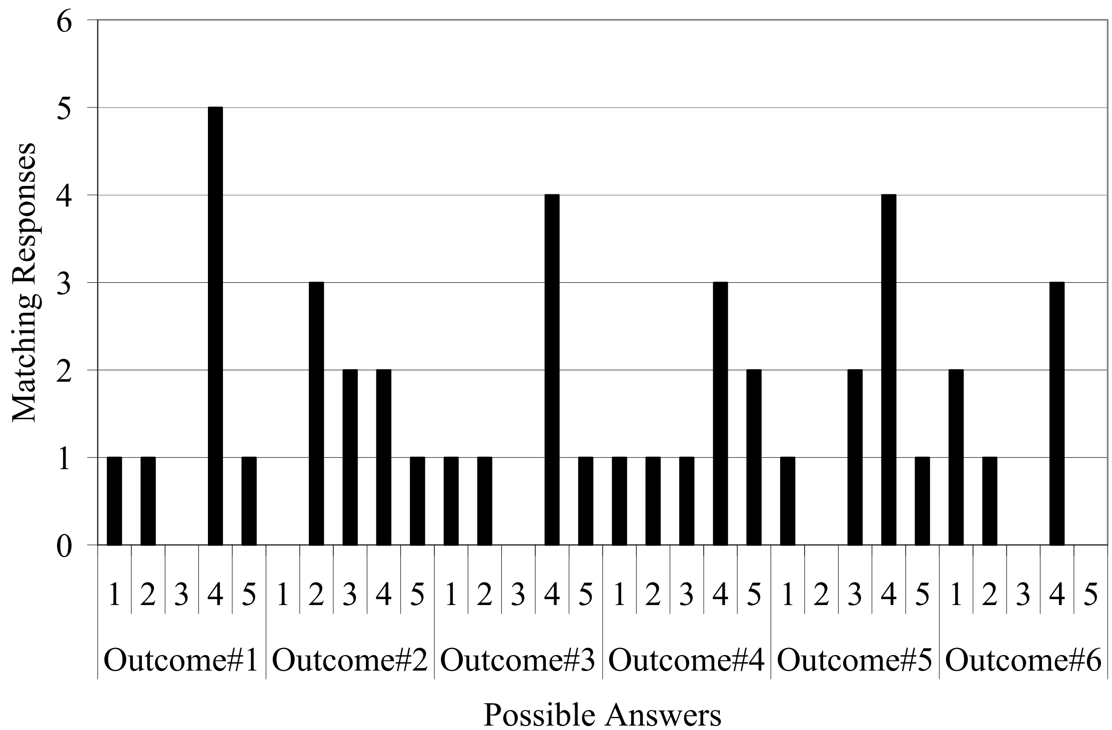


Figure 30. Alumni evaluation of achievement for outcomes 1-6.

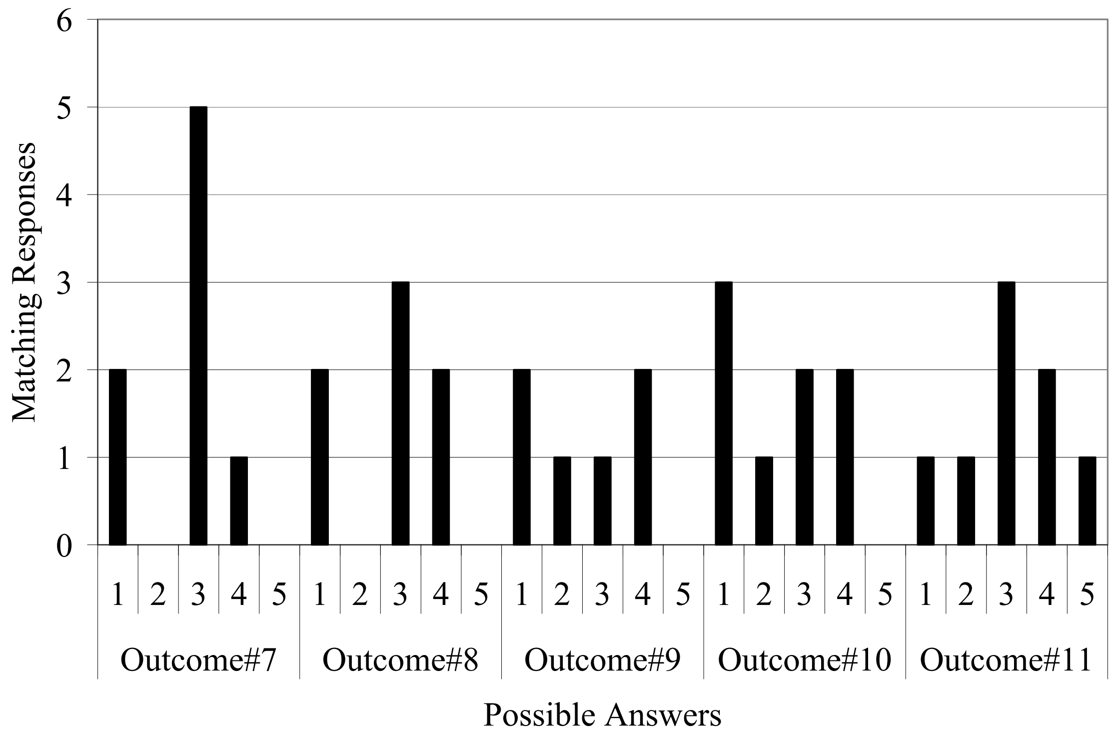


Figure 31. Alumni evaluation of achievement for outcomes 7-11.

Table 6. Average outcome score, alumni survey.

Outcome	Average Score
Outcome#1	3.5
Outcome#2	3.1
Outcome#3	3.0
Outcome#4	3.5
Outcome#5	3.5
Outcome#6	2.0
Outcome#7	2.6
Outcome#8	2.4
Outcome#9	1.9
Outcome#10	2.4
Outcome#11	3.1

Average scores for the outcomes ranged from 1.9 (outcome 9) to 3.5 (several outcomes). Outcomes 1, 2, 4, 5 and 11 all scored high, indicating that the alumni believe that these outcomes were well addressed and achieved. Outcomes 6-10 each scored relatively low indicating areas for possible improvement, with the caveat that the number of respondent was low. Improving Outcomes 6 and 8 has been addressed in the changes in the 2003 catalog year, which added CEE 158 and strengthened ENVE 175A/B. Outcome 7 is addressed through the implementation of team mini-design projects (as opposed to individual) throughout the upper division curricula and focus of presentation skills. The score on outcome 10 was surprising to the faculty, given the faculty's inclusion into most courses their current research programs. Also, as explained earlier, our teaching is rooted primarily in principles, not techniques. This may have contributed to the lower scores in outcomes 10. Finally, it is important to note that the major changes in the 2003 catalog year will not become fully apparent until the majority of survey respondents follow the revised curriculum. In this light the faculty have decided to monitor these results, but not make any major curriculum changes at this time until the results of the 2003 catalog changes can be completely understood. In the meantime, the faculty have made course-level changes to redouble the effort to bring in more design problems in under a team framework with the problems addressing contemporary issues. An additional focus will be on obtaining more significant relevant results in subsequent surveys, as cross comparison of the several surveys and assessments that were made reveals inconsistencies between the results.

Senior Design Survey

Beginning in 2006, a new survey evaluation targeted at measuring the 10 of the 11 outcomes (outcome 9, lifelong learning, could not be evaluated) was conducted by all Chemical and Environmental Engineering faculty attending the CEE senior design presentations. The faculty were asked to score the student/design team achievement of each ABET outcome for each design project (scores from 1 to 5, 5 as highest). Table 7 outlines the achievement as measured by the faculty. General satisfaction across all 10 outcomes is noted based on the average score of 4.4 out of 5.0 for all outcomes averaged together. Individual average outcome achievements ranged from 4.2 (outcomes 2 and 5) to 4.6 (outcomes 3 and 8) indicating broad achievement of all program outcomes scored during the capstone senior design course. While we are pleased with the overall scores for this design project, continued monitoring and evaluation of senior design outcomes is needed to ensure achievement of program outcomes in the capstone senior design course. In the future, it is expected that industry representatives be invited to the senior design presentations, and be asked to also provide their evaluation. All senior design presentations were video recorded for 2005 and 2006 and tapes will be available for the ABET site visit.

Table 7. CEE faculty evaluation of outcome achievement for each design presentation. Note that since ENVE 175AB and CHE 175AB were taught together and that the class included groups consisting of both CHE and ENVE student. Thus, the results shown are these of the entire class, i.e., including both CHE and ENVE majors.

Outcome	ABET Related Assessment	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Avg of all tean
1	An ability to apply knowledge of mathematics, science and engineering	3.90	4.13	4.42	4.44	4.50	4.40	4.30
2	experiments, as well as analyze and interpret data	3.90	4.38	4.08	4.43	4.40	4.00	4.20
3	An ability to design a system, component, or process to meet desired needs with realistic constraints such as economical, social, political, ethical, health and safety, manufacturability, and sustainability	4.20	4.88	4.50	4.69	4.40	4.80	4.58
4	teams	4.10	4.25	4.50	4.56	4.60	4.60	4.44
5	An ability to identitfy, formulate and solve engineering problems	3.90	4.00	3.92	4.25	4.30	4.63	4.17
6	An understanding of professioal and thical responsibility	4.10	4.88	4.50	4.31	4.30	4.80	4.48
7	An ability to communicate effectively	4.40	4.50	4.17	4.56	4.60	4.40	4.44
8	The broad education necessary to the understand the impact of enginering solutions in a global, economic, environmental, and societal context	4.40	4.50	4.50	4.56	4.50	5.00	4.58
10	An knowledge of contemporary issues	4.40	4.25	3.75	4.81	4.70	5.00	4.49
11	An ability to use the techniques, skills, and modern engieering tools necessary for engineering practice	4.30	4.63	4.25	4.25	4.63	4.30	4.39
	Average	4.16	4.44	4.26	4.49	4.49	4.59	4.40

Note: Each team score is an average of all students' achievement of outcome for given design team

Senior Exit Survey

A senior exit survey for the College has been conducted every year since 2000. Figure 32 summarizes the outcome based senior exit survey response for CHE for 2003-2005.

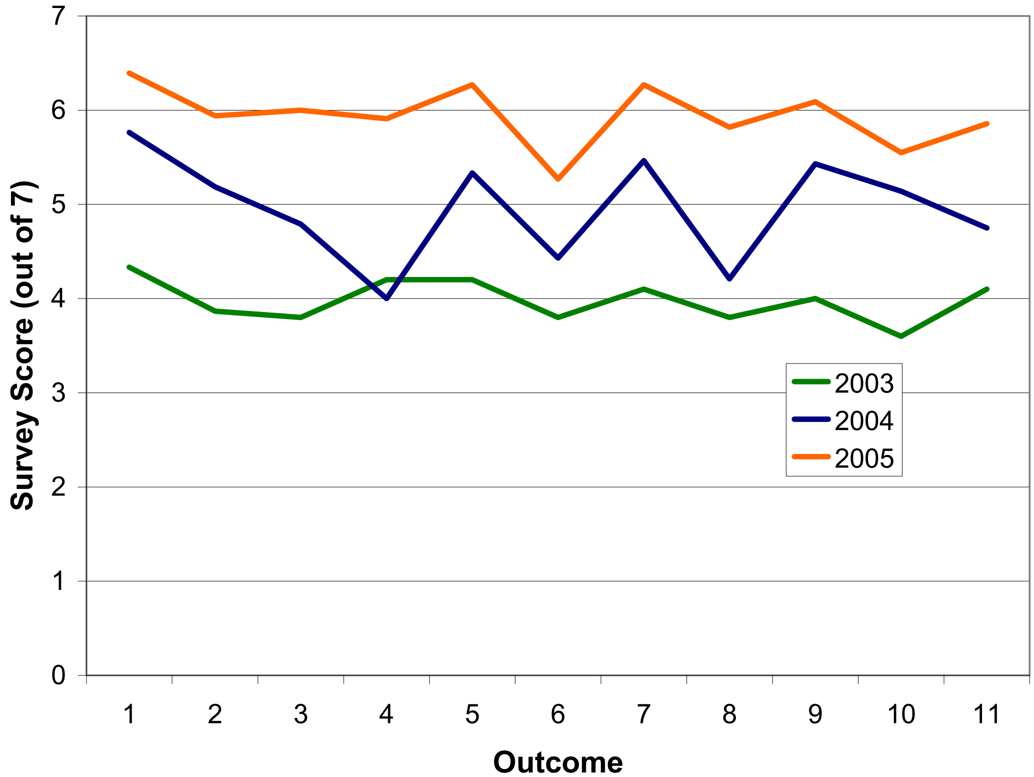


Figure 32. Summary of Senior Exit Surveys for CHE 2003-2005.

The surveys were generally given to seniors at the end of the senior design class, when they were in the best position to provide a critique of the education they received at UCR. The survey involved about 72 questions, out of which about 30 were used by the contractor hired to analyze survey results to assess the program outcomes, namely that graduates should demonstrate:

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

The survey results are shown in Figure 32. The faculty noted the following at the 2005 faculty retreat:

- Survey size was reasonable making statistical analysis adequate (total of 36 students replied (out of 43 possible) for three years.
- CEE faculty were pleased to see a general upward trend between 2003 and 2005.
- No major actions were taken as a result of the surveys alone other than to reiterate the need for continued monitoring.
- 2003 and 2004 exit surveys reflect catalog years before the major 2003-2004 curriculum change, which was meant to address specific objectives/outcomes of the current ABET criteria. Improvement in 2005 may be reflective of these catalog changes.
- The faculty acknowledged reinforced the need for CEE 158 to cover professional issues (outcome 6) such as ethics, career development, and need for lifelong learning,. This response was in part due to the chemical engineering exit survey data.

It was noted for CHE that outcomes 4 and 8 seem to be consistently lower than desired. A threshold of 5.0 for required action was instituted in 2006 by the ABET Committee. One more year of data was desired that would reflect changes in 2005 junior level courses.

It was noted that the lowest survey score areas addressed career services within the college. The ABET committee and faculty are confident that the Career Path Milestones program outlined in Section B.1.4 will overcome this student perceived shortcoming.

B.3.5 Other Outcome Analysis Mechanisms

The College and the Campus also perform assessments to evaluate student expectations and performance. At the campus level, the most significant assessment tool is the UC Undergraduate Experience Survey, or UCUES. This is a uniform questionnaire, which is administered at all UC campuses. Each campus also is able to add its own questions. The questionnaire is administered every two years, although there is some discussion of converting to an annual format. While UCUES does not enable us to compare our student responses directly with those of non-UC campuses, it does provide a basis for comparison with all of the other UCs with undergraduate programs (note that UC San Francisco has no undergraduate programs).

UCR also conducts an annual senior survey. This survey is not particularly valuable for assessing engineering outcomes because it is very general so that it can be administered to all seniors on the campus.

The campus has developed a single relational database (200 fields) to answer queries on student performance and trends, with longitudinal information. There is tiered access to different levels of detail; this protects the privacy of the students for whom data are gathered. As the database is populated with new information, it should be a valuable resource for providing information on the performance of engineering students in non-engineering courses and for evaluating their overall experiences.

The Bourns College of Engineering will begin to administer a new assessment tool in the fall of 2006. All incoming freshmen will receive a questionnaire designed to explore their expectations. In the spring, a second questionnaire will examine how well the actual experience matched the expectations.

B.3.6 Changes Made in Response to Assessments

The CHE program continuously strives to improve the overall student learning process. There have been a number of modifications made to the program since the last ABET visit – in response to changes in ABET criteria, our assessment findings, and other influences – as we continue to optimize the program and strive to meet our educational objectives and outcomes. The most significant changes were implemented in the 2002-2003 catalog year to ensure compliance of the CHE program with the ABET 2000 criteria and as a response to constituent feedback, most significantly from informal discussions with alumni, current students, and the CEE faculty. Another key objective for these changes was improvement of undergraduate retention. These changes are briefly discussed below.

Removed from the CHE curricula, after significant discussion and debate within the undergraduate education committee and subsequently among the full faculty, were Electrical Engineering 1A/1AL (Engineering Circuit Analysis) and Mechanical Engineering 10 (Statics). It was determined that the key desired concepts were covered in several physics courses, and that taking EE 1A and ME 10 was not as relevant for chemical engineering majors as originally thought. Instead, key concepts relevant to the FE exam would be reinforced in the newly introduced professional engineering course CEE 158. CEE would also cover other topics such as ethics, risk, management and environmental health and safety, regulatory issues not covered elsewhere. It was also decided to remove CHEM 110B (Statistical Mechanics and Kinetics) from the required courses, as it was redundant with other required courses for chemical engineering majors (Thermodynamics, CHE 100 and CHE 130, Kinetics CHE 122, and Physics PHYS 040ABC). Biochemistry 110B (General Biochemistry) was found to be too detailed for chemical engineering majors following the biochemistry option and therefore was removed. The fundamentals of cell metabolism and essential pathways were covered in Biology 121A and Chemical Engineering 124. Although Chemistry 5 (Quantitative Analysis), and Chemistry 125 (Instrumental Methods) were both good courses, our students were spending a disproportionate amount of time on these courses (eight hours of labs each). Also, not all aspects covered in CHEM 5 and CHEM 125 were relevant to engineers. Thus, we removed those courses from the list of the required courses for chemical engineering majors, following the chemistry option. Instead CEE students now take the new CEE 125 course (Analytical Methods for Chemical and Environmental Engineers) (4 units, with four hours of labs). The course teaches in a condensed format key analytical techniques that are directly applicable to chemical and environmental engineers. CEE 125 uses state-of-the art equipment available in the Department of Chemical and Environmental Engineering and trains students in techniques used by professional engineers. New technical electives were introduced (Chemistry of Materials (CEE 135, 4 units) and Green Engineering (CEE 132, 4 units)). The cumulative removal of these courses provided room for the introduction of CEE 10/11 (Introduction to Chemical and Environmental Engineering), designed to introduce the field of chemical, environmental and bioengineering to students during the freshman year; and CEE 158 (Professional Development for Engineers), designed specifically to increase the professional training of the students including career development, ethics, FE exam and concepts not covered by the program.

At that time, a new mentoring process was implemented (described in detail in section B.1) to ensure a minimum of quarterly faculty-student contact throughout their academic career. Every student was assigned to his or her own faculty mentor and must meet with the mentor quarterly to be eligible to enroll for the next quarter. The mentoring process allows students to identify possible career paths, internships, academic programs, etc., as described in detail previously.

The changes resulted in improved professional experience for the students. Informal discussion among recent graduates had indicated that there was a need for a more focused course on professional development and career choices. Therefore, CEE 158 was introduced into the curriculum to provide a platform for professional development with specific lectures on pathways toward attaining a PE license, attending graduate school, and alternative career choices in related fields. This course was also intended to provide a refresher course on key FE concepts prior to the students taking the exam. The course, combined with the senior design project, also provided an ideal platform to discuss engineering ethics.

UC policies allow students to change their catalog year for a subsequent one (but not for an earlier one). Several enrolled students have done so after the 02-03 changes were implemented, as they realized the benefits of the revised curricula. Even so, the first batch of students to begin under the 2002-2003 catalog program year graduated in June 2006. The formal quantitative assessment of the overall program was tested on a limited basis for the 2003-2004 year with the development of the course matrix (see Section B.3.3). Full implementation began in the 2004-2005 year, with an evaluation of the results presented in Section B.3.3. Therefore, limited assessment is available on the 02-03 changes in the program. Anecdotal evidence such as informal discussions with students and end of year group advising sessions has resulted in very positive feedback for these program changes. Evaluation of the 2005-2006 exit surveys will also provide an indication as to the overall success of the change.

While no formal changes to the program course sequence has been made since 2002-2003, many small changes have been implemented at the course level. Use of the end-of-quarter class assessments based on student feedback, student grades, and instructor evaluation provides a documented method for implementation of course level improvements. One such example is provided below as an example, for the Fall 2004 and Fall 2005 offerings of CHE 114, Fluid Mechanics. The matrix outcome analysis for Fall 2004 (Figure 33) is provided, along with assessment documentation by the instructor. This resulted in changes in the way fluid mechanics was taught in 2005. The evaluation of the effects of the changes as well as subsequent instructor's assessment are presented (Figure 34).

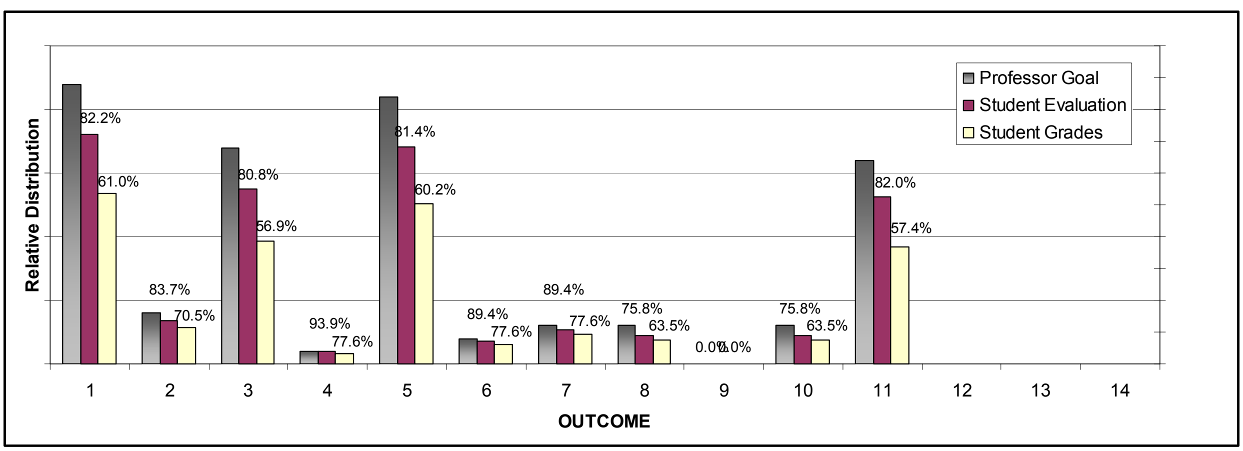


Figure 33. Matrix output for Fall 2004, CHE 114 course.

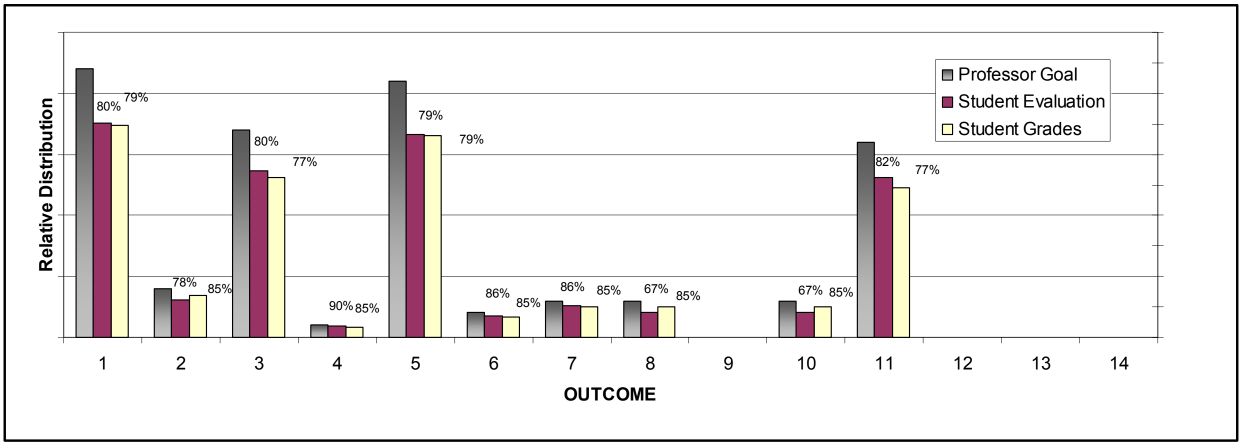


Figure 34. Matrix output for Fall 2005 CHE 114 course.

The following assessment was made by the instructor (Dr. Myung) after teaching the course in 2004 and reviewing the matrices. Changes were made in teaching the course the year after.

Assessment of CHE 114 for Fall 2004

Observations:

Objectives:
The student evaluation shows consistent reasonably scores (>70%) for all Objectives. However, the student grade shows that Objective 3, 4, 5 achieved moderate score (i.e. between 60 to 70 %) and Objective 6 and 7 achieved low score (<60%).

Outcomes:
The student survey shows consistent high scores (> 75 %) for all Outcomes. However, the student grades show that Outcome 1, 5, 8, and 10 achieved moderate score and Outcome 3 and 11 achieved low score.

Comments and suggestions:

The low student grade score (< 60 %) on Objective 6 and 7 suggest that different methods for solving of momentum balance with Newton's second law and derivation of basic relations such as Hagen-Poiseuille equation from Navier-Strokes equation needed more emphasis next time. These two Objectives will be emphasized by providing more examples during lectures to enhance the performance. The Objective 3, 4, 5 will be further enhanced by providing 1) more examples during lectures and 2) office hours with open door policy. Furthermore, review session will be scheduled prior to midterms and final to discuss the materials which will be covered by exams.

The low score (< 60 %) for Outcome 3 and 11 are primarily due to the fact that low emphasis on Objectives 6 and 7. Perhaps more practice problems for different fluidic systems would help the student to better understand the materials in order to achieve better performance in the exams which are keys to this evaluation theme. As indicated above, review session will be scheduled prior to midterms and final to discuss the materials which will be covered by exams.

The course matrix results for the 2005 offering of the course are shown in Figure 34 and the 2005 assessment below reflected on the changes and their effects.

Assessment of CHE 114 for Fall 2005

Observations:

Objectives:
The student evaluation and the student grade shows consistent high score (>70%) except Objective 9 which scored 67% in student evaluation.

Outcomes:
The student evaluation and the student grade show consistent high score (> 70%) accept Outcome 8 and 10 which scored 67 % in student evaluation.

Comments and suggestions:

Compared to last year, the survey shows a great improvement. I believed higher scores were achieved by providing 1) more practice problems during lectures; 2) review sessions prior to midterms and final; and 3) office hours with open door policy. The student evaluation on Objective 9 shows moderate score of 67 %. In order to further enhance the performance on Objective 9, practice examples on the prediction of fluidic mechanics behavior form tabulated experimental data will be given during the course. In addition, review sessions and office hours with door open policy will be continuously provided to students to achieve high performance.

This example shows how changes are being implemented within each course to ensure that course objectives are met and that continuous improvements are being made at the course level. Usually, the changes occurring each year at the course level are relatively modest. This is because the course has been subject to continuous improvements over several years, often by the same instructor. More substantial changes are seen after an instructor teaches the course for the first time, after changing the required textbook, or when the assessment reveals a consistent pattern over the years.

Some substantial changes (e.g., course syllabus, number of units) require faculty vote, and various institutional approvals. An example of such a change has been increasing the units from 2 to 3 for the CHE 160ABC laboratory courses in order to better more reflective of the amount of effort and to allow for more time spent on laboratory reports, student presentation and reinforce the laboratory component of our curriculum. In 2004, CEE faculty approved the unit increase from 2 to 3 credit hours, however, because of a clerical mistake, the change did not take effect until Fall 2006.

Discussion amongst the faculty at the 2004 faculty meetings with regard to ABET and program changes focused on the exit survey taken by the senior class. The results of the senior exit survey are posted in Figure 32 above. Given the small size of the respondents to both surveys, statistical evaluation to support major changes was difficult. There was a general satisfaction with the upward trend. Several discussions ensued at the college-wide ABET Committee, and it was decided rather to monitor for further trends in the upcoming classes as the database grows to better understand possible trends. The combined input from both the CHE and ENVE classes indicated a need for more formalized discussion of engineering ethics and the ability of students to understand the impact of engineering solutions in a global/societal context. It was decided that these topics would be formalized into CEE 158 as well as incorporated among the rest of the courses to the extent that each instructor could do so.

B.3.7 Improvements in Freshman Chemistry

Achievement of Outcome 1 depends heavily on coursework offered in departments not controlled by the Bourns College of Engineering. We have noticed that freshmen historically have had difficulty with the freshman series of courses in Chemistry (CHEM 1A, 1B, 1C). The failure rates for engineering undergraduates in CHEM 1A has been around 25% or so, with undergraduates in the sciences failing at a slightly higher rate.

These courses are structured primarily as lecture courses, with 3 hours of lectures per week, and an accompanying 3-hour laboratory component, amounting to a total of 4 quarter units. These courses are large service courses, and have total enrollments of 1300+ across all sections.

An experiment was conducted by the College of Natural and Agricultural Sciences to test the effectiveness of adding an hour of discussion on overall success rates in these classes. A number of calculus-ready students were selected, and the students were divided into two groups, only one of which was required to participate in an hour-long discussion section each week.

Each CHEM 1 discussion section of 20-25 students was led each quarter by one of three experienced TAs appointed by the Chemistry Department. For these discussion sections, students were required to complete homework problems assigned by the course instructor, took quizzes covering the lecture material, and participated in other appropriate activities designed to clarify lecture principles and concepts. Access to on-line practice exams was made available to students in these sections. As far as possible, students stayed in the same CHEM 1D discussion section for each of the three quarters of the course.

These students also participated in mandatory workshops throughout the year given by peer mentors who were trained and supervised by the Learning Center. Workshops focused on problem-solving skills, test-taking skills, library usage, and other university acclimatization issues. These workshops taught such skills not in the abstract, but in the context of the CHEM 1 course material. The students developed a sense of community with their peer mentor and other students in the group, and developed study strategies as academic partners for success in the sciences.

The results of this experiment are summarized in Table 8, which shows the failure rates (a D or F grade) for students who attended discussion sections ("participants") and those who did not ("non-participants").

Sections with no participants are shown as "non-participant sections." The third column ("participant section") shows the outcome for a section with between 50%-60% participants. This section had the smallest fraction of D/F grades.

A breakdown of the participant and non-participant D/F rates for the lecture-only section is shown in the last two columns. Clearly, the D/F rate for participants was by far the lowest of all the students in this course, even when compared with students in the same lecture section. Not all other variables were controlled, however. For example, the non-participants in this section included non-freshmen and some were repeating the course.

Given the clear evidence of the positive contributions that the discussion section has made to student success, BCOE has agreed to partner with the College of Natural and Agricultural Sciences to adding a discussion section to the CHEM 1A/B/C courses, and test its effects on student success in a regular quarter. If the outcomes are positive, we will explore the option of making the discussion a permanent feature of the course.

Table 8. Failure rates in traditional and enhanced approaches for Chemistry 1.

	Non-participant section 1	Non-participant section 2	Participant section	Rate for Participants Only in Participant Section	Rate for Non-Participants Only in Participant Section
CHEM 1A	110/292 (37.7%)	78/306 (25.5%)	42/319 (13.2%)	4/192 (2.1%)	38/127 (29.9%)
CHEM 1B	27/169 (15.9%)	60/198 (30.3%)	23/261 (8.8%)	4/132 (3%)	19/129 (14.7%)
CHEM 1C	24/105 (22.9%)	28/161 (17.4%)	10/230 (4.3%)	1/119 (0.8%)	9/111 (8.1%)

B.3.8 Material Available to ABET Examiners during Visit

The ENVE department will provide the following materials for review during the visit by the ABET Examiners:

- Course files, which will include syllabi, textbook, lectures notes, homework assignments, mid-term and final examinations, and examples of student work in homework and examinations. Each file will also include course matrix, and summary of student performance in achieving objectives and outcomes, and course assessment by the instructor.
- Minutes of selected meetings and discussions held by faculty and stakeholder groups in relation to the ABET assessment process.
- Survey forms used to measure attainment of course objectives and outcomes.
- Laboratory manuals describing experimental procedures.
- Health and safety manuals used in laboratories.
- Equipment lists.
- University evaluations of teaching by faculty members.
- Videos of final senior design presentations.

B.4 Professional Component

The Chemical Engineering program is structured to provide the necessary background in mathematics and basic sciences (chemistry, physics, and biology) with the intent of preparing our graduates for the 21st century. It includes a general education component consistent with the college and university requirements for the B.S. degree. Tables I-1 and I-2 in Appendix I list the Chemical Engineering curriculum and present details on the course and section size.

General Education

A major goal of engineering is to contribute to the welfare of society. This contribution is best made when students have a broad understanding of the Humanities and the Social Sciences (HMNSS). This understanding is derived from the study of world history; political and economic systems; the ethnic, cultural, and religious diversity of the peoples of the earth; the arts and letters of all cultures; the social and natural sciences; and technology. Although not a formal part of the required HMNSS course of study for engineering majors, this understanding is strengthened by a stringent requirement in written communication (ENGL 1A, 1B, 1C). The requirements in the Humanities consist of a minimum of three courses: one course in World History; one from Fine Arts, Literature, Philosophy, or Religious Studies; and one additional Humanities course. Breadth requirements in the Social Sciences are similarly structured: one course from either Economics or Political Science; one course from Anthropology, Psychology, or Sociology; and one additional Social Science course. In addition, the campus breadth requirement in Ethnic Studies has the option of being incorporated into the above, or standing alone as an additional course. For depth, at least two Humanities or Social Science courses must be completed at the upper-division level and, at least two courses must be from the same subject area (for example, two courses in History), with at least one of them being an upper-division course.

Mathematics and Basic Sciences

The environmental engineering curriculum is built on a foundation of courses in mathematics and the basic sciences, which are taken in the first two years at the University. The basic sciences and mathematics courses that were selected emphasize concepts and principles. Students acquire a strong grounding in Physics through PHYS 40A, 40B, and 40C. Each of these courses includes an extensive laboratory component. At the same time, students take a variety of basic sciences courses or introductory engineering courses that will provide them with the breath necessary to solve multidisciplinary problems. These include Programming (CS 10), Cell Biology (BIO 5A), for all students, and selected biochemistry and biology courses for students following the biochemical engineering and bioengineering options.

The chemical engineering curriculum is also based on solid grounds of chemistry. General chemistry education starts with the CHEM 1A, 1B, and 1C series which include laboratories. The students then acquire theoretical and laboratory experience in organic chemistry (CHEM 112A, 112B, 112C) which are the same courses taken by chemistry majors.

During the first two years, students take 5 courses in mathematics that cover multivariable differential and integral calculus. These courses, MATH 9A, 9B, 9C, and 10A and 10B, are followed by a course in ordinary differential equations, MATH 46. The basic mathematics knowledge will be later complemented with engineering mathematics and statistics in ENGR 118.

Engineering Sciences

Most of the courses in engineering sciences are taken after the student has acquired the necessary foundation in mathematics and the basic sciences. Several courses help students to become proficient in computer programming and the use of computer software. The computer knowledge acquired in CEE 10/11 (taken as freshman) and CS 10 (Introduction to Computer Science) is later reinforced in ENGR 118 (Engineering Modeling and Analysis), where students formulate computer models for engineering systems. Most courses taught in the junior and the senior year incorporate computer based problems and projects.

Engineering topics the taken either in the sophomore or in the junior year introduce students to the fundamentals of chemical engineering. Our curriculum incorporates solid foundations in transport phenomena, thermodynamics and breadth and depth in unit operations, kinetics, and process control. The chemical engineering curriculum emphasizes principles, however, each course trains the students to carry the concepts forward towards creative applications. In the fall and winter of the sophomore year (junior year for transfer), students learn basic mass and energy balances in CHE 110A and CHE 110B (Chemical Process Analysis), before learning chemical engineering kinetics (CHE 122). The curriculum then focuses on Thermodynamics (ENGR 100, CHE/ENVE 130), Transport Phenomena (CHE 114 Fluid Dynamics, CHE 120 Mass Transfer, CHE 116 Heat Transfer, and selected option specific engineering courses. In the fall quarter of the junior year, students take ENGR 118, a five unit course which teaches engineering numerical methods, formulation of engineering models and their solutions through the numerical methods.

Advanced engineering topics taken by seniors include applications of transport phenomena in Separation Processes (CHE 117) which includes computer aided process design using professional software (SuperPro Designer), and Process Control (CHE 118). In addition, the curriculum allows the student to mold his or her program of professional specialty studies by allowing each student to choose from a number of technical electives. Examples of these electives include Catalysis (CHE 102), Analytical Methods for Chemical and Environmental Engineers (CEE 125), Chemistry of Materials (CEE 135), Technology of Air Pollution Control (ENVE 134), and Green Engineering (CEE 132) for the chemical engineering option; Biochemical Engineering Principles (CHE 124) and Laboratory (CHE 124L), Cell Engineering (CHE 140) for the biochemical engineering option; Biosensors (CHE 150), Biochemical Engineering Principles (CHE 124) and a variety of upper division biology for the students following the bioengineering option.

In the senior year, CEE 158, Professional Development for Engineers, exposes students to professional ethics, risk management and environmental health and safety, regulatory issues. One of the course objectives is to prepare students for transitioning to a successful career. The importance of lifelong learning and professional registration is emphasized.

Laboratory Experience

As outlined in the previous section, engineering design is emphasized in each engineering course. Theoretical concepts are reinforced in laboratories.

The broad objectives of all laboratory classes are to reinforce concepts learned in lectures, provide hands-on experience in collecting data and operating engineering systems, challenge students in planning and conducting experiments, working in a team, practice and improve technical writing and oral skills. The laboratory courses are based on the idea that students are in the best position to appreciate engineering experiments only when they have familiarity with the underlying theoretical principles. Thus, the first engineering laboratory course, CHE/ENVE 160A (Chemical and Environmental Engineering Laboratory), is offered in the Spring quarter of the junior year. This course is designed to train students in basic measurement techniques, and their application to fluid mechanics and mass transfer systems. Students perform seven out of the ten available lab exercises on a rotating basis. CHE 160B and 160C work on a similar principle. CHE 160A is followed by CHE 160B (Chemical Engineering Laboratory), which offered in the fall of the senior year and CHE 160C, offered in the winter of the senior year. CHE 160B focuses on kinetics, reactor design, and heat transfer. Students further practice physical measurements, experimental design, critical analysis of results, and preparation of engineering reports. Experimental design, critical analysis of results, and preparation of engineering reports are emphasized. When applicable, students are asked to compare their results with previously published ones, or to use their experimental data to size a unit operation, or conduct and engineering design exercise. CHE 160C deals with laboratory exercises in separation processes and in process control. Students are required to use their experimental data for scale-up purposes or for an application in engineering design.

Additional laboratory experience is acquired in CHE 124L (Biochemical Engineering Laboratory) for students following the biochemical engineering option, Analytical Methods for Chemical and Environmental Engineers (CEE 125) laboratories for students following the chemical engineering option, and advanced biology for students following the bioengineering option. Selected additional technical electives include a lab section as well.

For a majority of students, the senior design project (CHE 175A and 175B) offers another opportunity to perform laboratory work. In many cases, the design project requires either to verify an assumption, to determine the property of complex mixture, or to construct a model system or a prototype for a proof of concept. The Department and the faculty have been very supportive in terms of funding such laboratory work and the necessary resources have been made available. The process usually starts with the students analyzing their needs for laboratory work. They will then go through a decision making process for the selection of the materials, for the determination of the best experimental design, and for the development of the experimental protocol. Usually some device, equipment, or a pilot plant/reactor will be constructed. All the steps challenge the creativity of the students and stimulate their analytical skills. This is usually a very enjoyable process for the students, which contributes greatly to their overall education experience.

Further laboratory experience is often acquired by our students while conducting research with our faculty, either extracurricular activity (summer internship, or part-time research assistantship during the academic year) or for course credit through CHE 190 Special Studies. This provide one more opportunity to acquire advanced laboratory skills in emerging research areas.

Design

Most CHE courses, including laboratory courses, incorporate design, which addresses real-world problems whose solution requires creativity and consideration of alternatives to achieve stated objectives. Most students are introduced to the concept of design in their sophomore or junior year through individual design projects in which students are asked to design a system or a component that satisfies specified constraints. Examples of courses that have a specific design project include, but are not limited to, Fluid Mechanics (CHE 114), Heat Transfer (ENGR 116), Engineering Modeling and Analysis (ENGR 118), Separation Processes (CHE 117), Process Control (CHE 118). Specific design projects are based on material covered in the course. The design usually includes the following components: a) converting the design problem into quantifiable statements, b) formulating the equations that govern the design, c) developing assumptions necessary for solving the problem, and collecting the necessary information from vendors, books, publications, etc., d) selecting a method for solving the design problem and solving the design problem (analytically, numerically, sometimes iteratively), e) critically reviewing the design and optimizing the design including ethical concerns and operation and maintenance considerations, and f) writing a summary report, and in selected cases presenting results in front of the class. These individual design projects prepare the students for the capstone design project.

The culmination of the students' design experience is the two-quarter capstone design course, CHE/ENVE 175A and 175B, in which students draw upon various aspects of their previous engineering science and design knowledge to address a meaningful design problem. Students learn to define the objectives (in a global context), explore the possible options, plan and conduct experiments if needed, formulate preliminary solutions, and evaluate the proposed alternatives with respect to economics, feasibility, societal, health and safety impacts, and sustainability. This approach may require a number of iterations before a final comparative solution is achieved. Senior design projects are always team projects (usually three students). Chemical and environmental engineering students are encouraged to form mixed groups to promote diversity and multidisciplinary approach. CHE 175A and 175B is run in a very professional manner. Each team maintains a chronological log of all project work (to demonstrate the evolution of their design), submit timesheets and bimonthly reports consisting of 10-minute oral presentations (similar to an internal review in a consulting firm) and a 1-3 page technical memo. Bimonthly oral presentations as well as an end-of-first-quarter team oral presentation (15-20 min) are critiqued to provide feedback for developing effective communication skills. The first quarter (CHE 175A) focuses on project (concept) analysis, preliminary evaluation (economical and technical), data and literature collection, preliminary process design and evaluation, and becoming functional in simulation software packages such as PROII and SuperPro for modeling of an entire treatment plant. The first quarter also includes risk analysis, occupational health and safety of treatment systems, environmental and ethical concerns, sustainability concepts and operation and maintenance considerations. The second quarter (CHE 175B) of the capstone design course focuses on the detailed engineering design of the process (equipment sizing and specification, etc.), comprehensive profitability evaluation and process optimization, in addition to ethics issues in the profession. In some cases, students build a prototype of their design concepts and prove the concept by laboratory experiments and obtain the kinetics of a treatment system required for scaling up to a full-scale system using simulation software to model steady state processes. Students also learn to use other simulators such as DYNSIM, which provide transient responses related to startup, modifications, or shut down of their environmental treatment systems. Students are provided with the skills for conducting group meetings, and brainstorming in an ethical and professional manner. Monitoring and assessment of ethical and professional conduct are done with written and confidential self-group assessments, which are provided to the instructor and done twice each quarter. This provides students with a means to learn to work productively in teams by addressing professional and personality issues that may arise throughout the capstone design course (much like conflicts which may arise in a real world setting). The course concludes with a formal oral presentation (30-40 min), which is evaluated by the faculty and a comprehensive written technical report.

Career Preparation

Appendix II lists the professional engineering societies and other relevant student organizations that help students build professional skills and networks. The Appendix also describes the Career Center, whose services include assistance with resume preparation, interviewing skills, internships, and placement. The Career Center's mock interview service is conducted in conjunction with student professional societies, including the Society of Women Engineers and the IEEE. In 2005, companies that provided interviewers for this program were Fleetwood Enterprises, Kroger, and Raytheon. In 2006, participating companies were Ambryx Biotechnology, the City of Riverside, Fleetwood, Kroger, and Luminex.

B.5 Faculty

Currently, the Department of Chemical and Environmental Engineering has 16.5 faculty. This includes 0.5 FTE for a split appointment with Chemistry (Haddon), several faculty with significant administrative commitments (Matsumoto, Norbeck, Schultz), and 3 new faculty hired in 2005-2006 for the Bioengineering program. The latter 3 did not contribute to the teaching reviewed for this ABET review (hence no biographies are provided) and together with Prof. Schultz they will be moving to the Department of Bioengineering, to be formed in summer 2006. Bioengineering faculty may later contribute to teaching courses taken by environmental engineering students (e.g., selected electives). Thus, the core chemical end environmental engineering faculty is about 12 faculty. Because we are a joint department with many courses cross-listed between the chemical engineering or environmental engineering programs, it is not possible to separate the faculty into the two respective programs. Four faculty (Cocker, Matsumoto, Norbeck, Walker) have a strong environmental engineering background, while the rest of the faculty (Chen, Deshusses, Haddon, Kauffman, Mulchandani, Myung, Schultz, Wu, Yan) have a chemistry/chemical engineering background. A faculty search is currently underway to add two or more new faculty in the department.

The department also employs one full-time lecturer (Tam) and several part-time lecturers (Perina, Lee, Abi-Samra, Sheng) and one adjunct professor (Miller). Two lecturers are licensed Professional Engineers (Sheng, Abi-Samra), one is a registered geologist and hydrologist, and three faculty are EIT. The biographies of the faculty and lecturers are provided in Appendix I.C. Table I-3 in the Appendix provides a Faculty Workload Summary for the 2005-2006 AY.

All of the department faculty members are very actively engaged in scholarly research, consistent with the mission of the institution. In addition to being actively engaged in teaching undergraduate and graduate students, members of the department faculty supervise research of graduate students pursuing M.S. and Ph.D. degrees, and provide research opportunities to undergraduate students in their research laboratories. Two of the faculty (Norbeck and Deshusses) have received the prestigious Chancellor's Award for Excellence in Fostering

Undergraduate Research. NSF-REU (i.e., supplement for undergraduate research) are systematically requested. Faculty are actively conducting research, publishing research papers in the leading journals in their fields of expertise, attending technical conferences, and generating extramural funding for research from various local, state, federal, and industrial agencies. Several faculty serve as editors and are on editorial boards of major journals. All faculty are very active professionally, for example in their respective societies (see biographies and Table I-4). The CEE department is one of the most active and successful departments on campus, in terms of research and funding per faculty.

Faculty members have resources from initial complements, "various donors" funds, and contract and grant awards to travel to meetings and conferences in their disciplinary areas or in engineering education. Some additional funds are available from the College, the campus, and the Faculty Senate. The high funding per faculty is a good indication that professors are able to maintain currency in their fields.

The program faculty is extremely competent at teaching and is fully engaged in all curricular matters pertaining to the undergraduate program. When needed, the department provides resources to further increase teaching competence and effectiveness. For example, several junior faculty have attended workshops on how to improve their teaching, and recently, lecturer K. Tam attended a weeklong course on teaching sustainability and green engineering which greatly benefited her teaching of CEE 132. After these workshops, faculty members share their experience with others during the faculty meetings usually held on a weekly or bi-weekly basis. Funding for these activities is provided from departmental or college funds, on an as-needed basis.

A normal classroom teaching load in the Department of Chemical and Environmental Engineering is three formal undergraduate or graduate lecture or laboratory courses plus three graduate specialty courses (CEE 250-260 series) per year. With minor exceptions (e.g., laboratories, ENGR 118, CEE 158), the formal courses are all 4 credit hours. The specialty graduate courses (CEE 250-260 series) are usually 1-2 credit hours, with instruction given in an interactive style, such as seminars or discussions. They promote active learning, and train graduate students in their specialty area.

Deviations from the above teaching load include the following:

- New faculty members are usually given one quarter teaching relief when joining UCR in order to get their research started. New faculty may also delay teaching their graduate specialty course until a significant body of graduate students is established in their research specialty.
- Consistent with campus practice, one quarter formal lecture course relief is provided for the Department Chair, Graduate Advisors, Associate Dean. Center Directors, faculty members with split appointment or with special administrative duties may have a different agreement. No course relief is provided for the Undergraduate Advisor.

Teaching assignments are made by the Department Chair in consultation with the faculty, usually in the Spring and are finalized in the Summer. Usually, a faculty member will teach the same courses several years in a row. This is to maximize teaching quality and effectiveness. Also, continuity in teaching is an important factor in the assessment of our courses and program.

Teaching assistants are provided for undergraduate courses with enrollment above 10 students only. Except for the laboratories where TA involvement is heavy in ensuring proper handling of the laboratory equipment, the TAs duties are usually limited to grading homework and being available during office hours for students questions. CEE faculty grade mid-terms and final exams, hold office hours, and usually handle all discussion hours rather than leaving discussions to the TA. In some cases, a grader is provided instead of a TA. This usually increases the workload of the faculty.

Faculty are accessible to students in class, in teaching laboratories, during office hours, on appointment and via e-mail at all other times. Faculty are very active in encouraging and supervising research carried out by undergraduate students in their research laboratories which provides further opportunities for student-faculty contact. All students in the program are required to meet with their faculty mentors for a one-on-one mentoring session at least once every quarter. Faculty is thus actively engaged in ensuring student advising and retention in the program.

Faculty and lecturers are involved in various student clubs in the department and college. Examples include AIChE, Air & Waste Management Association (AWMA), and the Society of Women Engineers (SWE).

B.5.1 UCR Scholarship of Teaching Series

The UCR Office of Instructional Development has established a Scholarship of Teaching lecture series for faculty and instructor to enhance the quality of teaching throughout the campus. Presentations highlight

- The effective use of current and emerging instructional methodologies and technologies.
- Strategies for the introduction of active learning, peer to peer learning, and collaborative approaches in teaching.
- Pedagogical approaches to enhance student engagement and optimize student learning outcomes.
- Effective approaches to teaching and learning in and outside of the classroom.
- The engagement of teaching community in the collaborative, scholarly examination of their practice as teachers.
- The development of assessment tools to measure student learning outcomes.
- The development of a campus culture of evidence regarding our academic programs.

Some lectures are presented by faculty or administrators from UCR, and some by outside presenters. Many deal with new teaching resources and technologies available for use at UCR.

For a complete list of all topics presented in the 2005-2006 academic year, please see http://www.oid.ucr.edu/OIDSpeakerSeries.html.

B.6 Facilities

Instructional classrooms are provided by the University and the College of Engineering and centrally administered by the campus. Typically, a tentative list of course offerings is prepared in the spring quarter for the following academic year. This list is developed by the Chair of the department with input from the faculty. Most classrooms offered by the campus and the college are media-equipped, facilitating computer and internet access for the classroom instructor.

The CEE faculty members believe that the laboratory experience is an extremely important component of engineering education. The Chemical Engineering program has, since its inception, devoted significant efforts to the continuous development of its laboratory courses and has equipped the facilities with state-of-the-art equipment. The following principles have guided these efforts:

- The labs must reflect state-of-the-art technology in analytical equipment, computers, software and instrumentation – not only in terms of technology, but also in methodology and tools used in engineering practices.
- The labs must reflect a balanced Chemical Engineering program.
- The equipment and software tools employed in Chemical Engineering labs should be consistent with those commonly used in practice.
- Certain teaching activities may be conducted in faculty research laboratories. This allows our students to be exposed to the current research frontier even before entering graduate school.

The chemical engineering instructional laboratories are housed in the B-wing of Bourns Hall. The building is relatively new (1995) and offers outstanding research and educational opportunities. Most of the lab space for chemical and environmental engineering instruction is in two dedicated laboratories, B108 and B134 (see pictures below). These two adjacent labs provide a total of about 3,000 square feet, which are shared between chemical and environmental engineering laboratory classes. Additional space is being organized and will come on-line in the latter part of AY 06-07.

Instructional laboratories not taught in Bourns Hall B108/B134 include CHE 124L, and CEE 125, which are conducted in CEE research laboratories (mostly located on the 3rd floor of Bourns Hall), and at the College of Engineering, Center for Environmental Research and Technology (CE-CERT), respectively. In addition, depending on their senior design project, students in CHE 175AB may also use faculty research laboratory facilities. The reason for this is that these often require specialized equipment that is used mostly for research. The CEE research laboratories (total >15,000 sq ft) are fitted with the latest research equipment.

A summary of some of the equipment and instrumentation available for chemical engineering laboratory course is given below. Most of the instructional equipment and instrumentation was purchased between September 1992 and June 1994 from Armfield and has been adequately maintained by trained technicians since. Selected instruments have been upgraded with data loggers.

- Reynolds Apparatus
- Pipe Friction Apparatus
- Drag Coefficients of Particles Apparatus
- Pipe Network Apparatus
- Fixed and Fluidized Bed Apparatus
- Fluid Mixing Apparatus / Determination of mass transfer coefficient
- Multi-Purpose Teaching Flume
- Multi-Purpose Pump Test Rig
- Gaseous Diffusion Apparatus
- Liquid Diffusion Apparatus
- Wetted Wall Absorption Apparatus
- Fluid Mixing Apparatus
- Plug Flow and Ideally Mixed Reactors Apparatus
- Heat Conduction Apparatus
- Thermal Radiation Study Bench
- Free and Forced Convection Heat Transfer
- Concentric Tube Heat Exchanger
- Distillation Apparatus
- Process Control Apparatus
- Dissolved Oxygen Meter and Probes, Orion Model 860
- Shimadzu Total Organic Carbon (TOC) Analyzer, Model TOC-5050
- HP 5890 Series II and 6890 Gas chromatograph
- Thermo Environ. Inst. Inc Oxides of Nitrogen Analyzer
- Spectrophotometers, Milton Roy Spectronic 20 Model D

Figure 35 shows some of the resources available for CEE instruction.

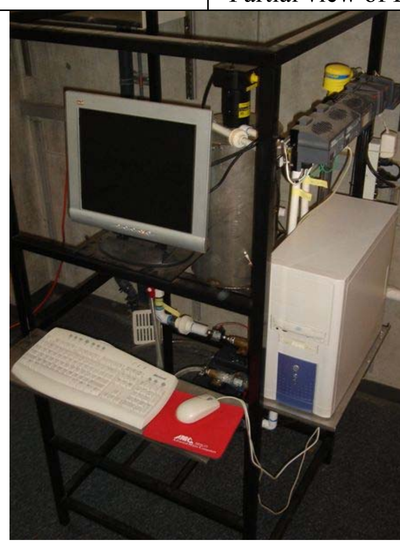
Computing facilities are excellent. Currently the department has one computing laboratory fully dedicated to CHE/ENVE students. Room B255 located in Bourns Hall (about 1600 sq ft) houses 42 networked computers and a networked printer (Figure 36). Students have access to the facility 24 hours per day. The computers run Windows XP and have most recent versions of MS-Office, MATLAB, AUTOCAD, SuperPro Designer and other various engineering applications. The lab is also equipped with LANSCHOOL – a software program that enables monitoring of all computers with an ability to broadcast material from the instructor's computer. This facilitates class room instruction and is conducive to effective learning of software tools.

As part of the 05-06 instructional support, funds have been received to purchase 12 additional computers, bringing the total to over 50 stations. We will split the computers into two laboratories (e.g., 40 PCs in one room, 14 in the other one) to avoid disruption of computer access when CEE classes are taught one of the computer labs. The room with the smaller number of computers will have a quiet area for students to study.


Partial view of B134


Partial view of B108


Distillation apparatus


Process control apparatus (level and temperature control with DAQ)


Fermenter (for CHE 124L)


Pipe network apparatus


CSTR apparatus with data acquisition on a laptop

Figure 35. Pictures of selected instructional laboratories and instructional equipment.

Figure 36. Pictures of the chemical and environmental engineering computer laboratory (B255).

B.6.1 Accommodating Future Growth

Bourns Hall is approximately 15 years old and provides more than 100,000 square feet of office, classroom, and wet laboratory space for the Bourns College of Engineering. Engineering Building II is one year old and has 98,177 assignable square feet of office, classroom, and dry lab space. These two buildings are ample to accommodate the College faculty, staff, and students at this time.

The University's plan calls for the opening of a Materials Science and Engineering Building in 2008 (Figure 37). This building is designed at 76,940 square feet, including laboratory, office, and classroom space. Laboratory facilities will include a larger clean room nanofabrication facility than the one currently available in the B-wing of Bourns Hall. The building site currently is a recreational field across the street from Bourns Hall.

Formal plans for Engineering III and Engineering IV are not yet in place. Engineering III could be ready for occupancy as early as 2012.

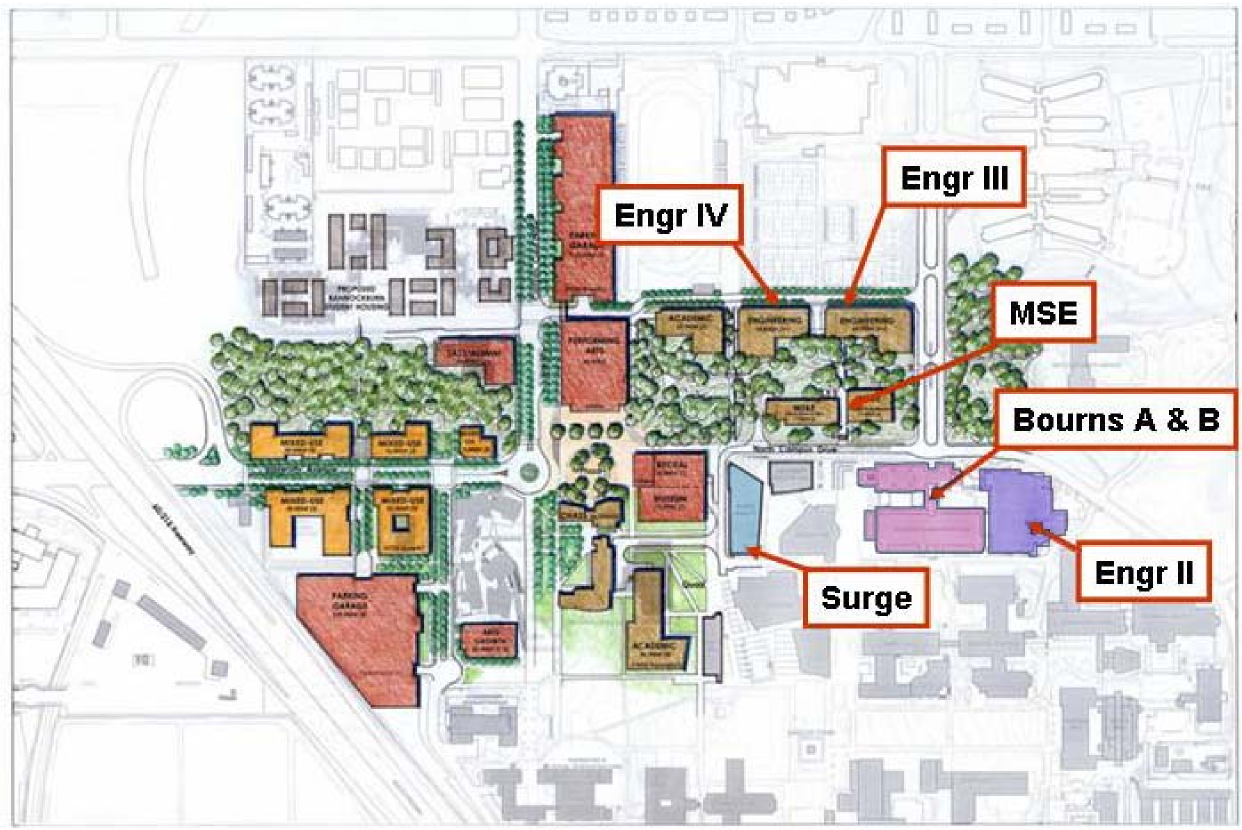


Figure 37. Locations of Bourns Hall (existing) and Engineering II (existing), with the planned Materials Science and Engineering (MSE) Building (2008) and future Engineering III and Engineering IV locations. Surge was the temporary home of the Computer Science and Engineering Department before Engineering II opened in the summer of 2005. The College now has no offices or labs in Surge.

B.7 Institutional Support and Financial Resources

The University, Campus and College provide a good balance of central leadership and support to enable the program to achieve its missions and goals. As articulated in Section B.6, our students have access to excellent facilities within the Department and the Campus. Support for these facilities, including the requisite staffing support is described. below.

B.7.1 Budget Processes

The University of California, Riverside has a multi-step budget development process. The major steps in the annual process are:

February:	Campus Budget Call Letter is distributed and meetings held with academic units to discuss faculty renewal models
March:	Comprehensive Planning Documents are submitted to the Executive Vice Chancellor
April:	Individual unit hearings with senior UCR management

May: Input and feedback from Faculty Senate Committee on Planning and Budget to EVC
June: Final unit budgets announced

In response to the February Budget Call Letter, the Dean's Office in the Bourns College of Engineering requests budget proposals from each academic department in the College. These proposals include undergraduate and graduate student projections, course load information, staffing requirements and needs for additional supply, travel and miscellaneous expenses. Any additional resources requested are presented in the context of departmental Five-Year Plans. In this way, departments demonstrate their progress in attaining Five-Year goals and request the resources required for the next year to maintain that progress. In most cases, departmental current year (Permanent) budgets are the starting points for the next fiscal year's budgets. UC Permanent Budget resources do not have expiration dates and are used to fund long-term commitments from the University. In addition to Permanent funds, departments can request Temporary funds from the Dean's Office either during the budget proposal cycle or during the fiscal year for exceptional (one-time) expenses. The Dean's Office evaluates annual departmental funding requests and submits a combined budget proposal from the College in late March to the EVC's Office. After the final College budget is announced in June, any additional resources approved are allocated to the departments beginning the start of the fiscal year, July 1st. Temporary funding requests approved during the fiscal year are allocated at the time of approval or are reimbursed to departments after expenses are incurred. Each department is responsible for monitoring its expenses and projected ending balances during the fiscal year.

B.7.2 Faculty Professional Development

Faculty professional development funds are provided to assistant professors as part of their faculty start-up packages. The University has a normal sabbatical program to maintain faculty currency. In addition, the Academic Senate provides travel assistance grants, and the campus provides grants to support innovative teaching. Also, funds area available to all faculty from their faculty support accounts, which are funded by a number of activities including a (small) portion of indirect costs generated by grants and contracts.

B.7.3 Maintenance and Operation of Facilities and Equipment

The Bourns College of Engineering provides one-time equipment funds annually to upgrade, acquire or maintain equipment. A brief recent history of funding is provided below:

In the current year (2005-2006), the College provided $75,500 for the department to acquire (1) Additional computers for student computing laboratory, (2) Air quality monitoring instrumentation for ENVE 160B, (3) New spectrophotometer.

In 2004-2005, the College provided $42,000 for the department to acquire (1) Additional computers for student computing laboratory, (2) Maintenance on our Armfield instructional equipment, (3) pH and dissolved oxygen meters for undergraduate laboratories

In 2003-2004, the College provided $40,000 for the department to acquire (1) Atomic absorption analyzer, (2) Digital microscope for undergraduate laboratories

In previous years, over $100,000 was provided by the College to acquire various equipment with dual use (research and instruction) which included HPLC, Zeta-potential measurement equipment, computer server, etc.

Funding for the capstone senior design projects, when needed is covered by the department.

Maintenance of all general laboratory equipment and instruments is the responsibility of the Laboratory Manager for Chemical and Environmental Engineering. The Lab Manager and the Teaching Assistants check equipment and instruments used for laboratory instruction at the beginning of each quarter by performing experiments similar to those that are to be conducted by the students. Replacement of parts and maintenance are performed. Calibration of analytical instruments is part of the beginning of the quarter checks. Electronic instruments that seem to be in need of service are brought initially to the College's electronic shop. If repair or service can be done there, it is completed there. Otherwise, manufacturer-authorized service technicians service the equipment/instruments. Funding for small maintenance is from the general operating budget of the department, while larger maintenance projects are scheduled and part of the budget request process (see allocations above).

B.7.4 Support Personnel and Institutional Services

The program is supported by full time departmental staff, part-time student assistants, teaching assistants, readers, and graders as needed to support individual courses and program administration. The College provides Student Advisors who interact with program students, monitor academic progress, enable registration, and direct them to appropriate services on campus for tutoring, career counseling, etc. Tutoring service is provided at the Learning Center and in the student dormitories (free for students living on campus). The College has developed a Professional Development Milestones Program to enable each program student to prepare for internships, job interviews, and research opportunities. The College provides funds to support teaching assistants, graders, and readers, assigned based on course enrollment and need for laboratory supervision. Teaching Assistants conduct discussion sessions in which students are exposed to additional problems and concepts to reinforce material covered in lectures, and to enable students to complete course assignments. All instructors and teaching assistants maintain posted office hours for assisting students outside scheduled classes. The program has a designated Undergraduate Advisor (currently Dr. Cocker) to oversee curricular matters and to offer advice on curricular issues.

B.8 Program Criteria

Chemical Engineering program criteria, as defined by the American Institute of Chemical Engineers, dictate that graduates must have:

1. thorough grounding in chemistry and a working knowledge of advanced chemistry such as organic, inorganic, physical, analytical, materials chemistry, or biochemistry, selected as appropriate to the goals of the program;
2. working knowledge, including safety and environmental aspects, of material and energy balances applied to chemical processes; thermodynamics of physical and chemical equilibria; heat, mass, and momentum transfer; chemical reaction engineering; continuous and stage-wise separation operations; process dynamics and

control; process design; and appropriate modern experimental and computing techniques.

Chemical engineering students satisfy the Chemical Engineering criteria by taking and successfully passing a variety of required courses in science and engineering. Often, the chemical engineering program criteria are reinforced in either laboratory courses (ENVE 160ABC series), or in technical electives, and are further integrated in the senior design project. Details are provided in Table 9.

Table 9. Fulfillment of Chemical Engineering program criteria defined by the American Institute of Chemical Engineers.

Program Criterion for Chemical Engineers. Graduate must have a:	Course(s) in which the required materials are covered and practiced.
Thorough grounding in chemistry and a working knowledge of advanced chemistry such as organic, inorganic, physical, analytical, materials chemistry, or biochemistry, selected as appropriate to the goals of the program;	CHE students are required to take one year of general chemistry CHEM 1ABC (which include laboratories). In addition, all CHE students take one year of organic chemistry (CHEM 112A, 112B, CHEM 112C). These courses are the same as those taken by chemistry majors. Additional advanced chemistry courses include physical chemistry taught in CHE 100, and option specific advanced chemistry as follows: -Chem. eng. option: analytical methods (CEE 125, required), chemistry of materials (CEE 135, optional) or green chemistry and engineering (CEE 132, optional) -Biochem. engineering. option: biochemistry (BCH 110A, required), chemistry of materials (CEE 135, optional) or green chemistry and engineering (CEE 132, optional) -Bioeng. option: biochemistry (BCH 110A, BCH 110B required)
Working knowledge, including safety and environmental aspects, of material and energy balances applied to chemical processes	Material and energy balances are first introduced in CHE 110A and CHE 110B (Chemical Process Analysis), and later emphasized in the three transport classes (CHE 114, 116 and 120) and advanced thermodynamics (CHE 130). Safety and environmental aspects are taught in most courses throughout the curriculum, but is emphasized during the senior design project (CHE/ENVE 175AB).
Thermodynamics of physical and chemical equilibria,	All CHE students take two course in thermodynamics (CHE 100 and CHE 130).
Heat, mass, and momentum transfer; chemical reaction engineering	Our curriculum requires student to take fluid mechanics (CHE 114), mass transfer (CHE 120), heat transfer (CHE 116), and kinetics (CHE 122). The concept learned in these courses is reinforced in the CHE 160ABC laboratory series which includes experiments in heat, momentum and mass transfer and reaction engineering. Additional elements of chemical reaction engineering are included in upper division courses (e.g., CHE 124: biochem. eng., CHE 102 catalysis, both optional) and in the senior design.
Continuous and stage-wise separation operations	This is covered in detail in CHE 117, Separation Processes. The course includes computer aided process design using the software SuperPro Designer. The laboratory CHE 160C focuses on unit operations.
Process dynamics and control	Process dynamics and control is covered in a dedicated course (CHE 118). The laboratory CHE 160C includes a newly developed experiment for hands-on practice of process dynamics and control. Depending on the project, students may practice process dynamics in senior design.
Process design	Design is integrated throughout the curriculum. The ultimate design experience is concentrated in the senior design (See Section B-3,

	outcome 3, and Section B.4 for further detail).
Appropriate modern experimental and computing techniques	Modern experimental techniques are taught primarily in laboratory courses, CHE 160ABC and CHE 125 (optional). A majority of students also conduct extracurricular research in the CEE research labs, which exposes them to the advanced experimental techniques. Modern computing techniques are first introduced in ENGR 118 and later applied for generating laboratory reports, solving homework problems. All students acquire a working knowledge of computer aided process design using the latest version of SuperPro Designer in CHE 117 (Separation Processes) and in senior design (CHE 175AB). See also Section B.4 and Section B.3 outcome 11.

Appendices

- Appendix I – Additional Program Information
    - IA – Tabular Data for Program
    - IB – Course Syllabi
    - IC – Faculty Curriculum Vitae

- Appendix II – Institutional
    - IIA – Background Information Relative to the Institution
    - IIB – Background Information Relative to the Engineering Unit

Appendix I

IA. Tabular Data for Program

TABLE I-1
COURSE REQUIREMENTS OF CURRICULUM

BASIC-LEVEL PROGRAM
Chemical Engineering (Biochemical Engineering Option)

Year; Semester or or Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics		Hum. & Soc. Sci.	Other
				Engrg Science	Engrg Design (✓)		
1; Fall	MATH 9A – First Year Calculus	4					
	CHEM 1A – General Chemistry	4					
	CEE 10 – Intro to CHE/ENVE Engineering			2	(✓)		
	ENGL 1A – Beginning Composition					4	
1; Winter	MATH 9B – First Year Calculus	4					
	CHEM 1B – General Chemistry	4					
	PHYS 40A – General Physics	5					
	ENGL 1B – Intermediate Composition					4	
1; Spring	MATH 9C – First Year Calculus	4					
	CHEM 1C – General Chemistry	4					
	PHYS 40B – General Physics	5					
	ENGL 1C – Applied Intermediate Composition					4	
2; Fall	MATH 46 – Intro. to Ordinary Diff. Equations	4					
	CHEM 112A –Organic Chemistry		4				
	CHE 110A – Chemical Process Analysis			3			
	PHYS 40C – General Physics	5					
2; Winter	MATH 10A – Calculus of Several Variables	4					
	CHEM 112B – Organic Chemistry		4				
	CHE 110B – Chemical Process Analysis			3	(✓)		
	BIOL 5A/LA – Intro to Cell & Molecular Biology	4					
2; Spring	MATH 10B – Calculus of Several Variables	4					
	CHEM 112C – Organic Chemistry		4				
	CS 10 – C++ Programming			4			
	CHE 122 – Chemical Engineering Kinetics			4	(✓)		

(continued on following page)

TABLE I-1 (Continued)
BASIC-LEVEL PROGRAM
Chemical Engineering (Biochemical Engineering Option)

Year; Semester or Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics		Humanities & Social Sciences	Other
				Engrg Science	Engrg Design (✓)		
3; Fall	CHE 114 – Fluid Mechanics			4	(✓)		
	ENGR 118 – Engineering Modeling			5	(✓)		
	BCH 110A – General Biochemistry		4				
	General Elective – H&SS					4	
3; Winter	CHE 100 – Engineering Thermodynamics			4	(✓)		
	CHE 120 – Mass Transfer			4	(✓)		
	General Elective – H&SS					4	
	General Elective – H&SS					4	
3; Spring	CHE 116 – Heat Transfer			4	(✓)		
	CHE 130 – Advanced Thermodynamics			4	(✓)		
	CHE 160A – Chem. & Envi. Engineering Lab			2	(✓)		
	General Elective – H&SS					4	
4; Fall	BIOL 121 – Microbiology	4					
	CHE 117 – Separation Processes			4	(✓)		
	CHE 124 – Biochemical Engineering Principles			4	(✓)		
	CHE 160B – Chemical Engineering Lab			2	(✓)		
4; Winter	CHE 175A – Senior Design Project			4	(✓)		
	CHE 160C – Chemical Engineering Lab			2	(✓)		
	CHE 118 – Process Dynamics and Control			4	(✓)		
	CHE 124L – Biochemical Engineering Lab			2	(✓)		
	CEE 158 – Professional Development for Engineers			3			
4; Spring	CHE 175B – Senior Design Project			4	(✓)		
	Technical Elective*			4	(✓)		
	General Elective - H&SS					4	
	General Elective - H&SS					4	
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		59	16	76		36	
OVERALL TOTAL FOR DEGREE (EQUIV. SEMESTER CREDITS)		39.3	10.7	50.7		24.0	
PERCENT OF TOTAL (187 quarter hours for degree)		21.0	5.7	27.1		12.8	
Must satisfy one set	Minimum semester credit hours	32		48			
	Minimum percentage	25		37.5			

* The technical electives for the Biochemical Engineering Option include CEE 132, CEE 135, CHE 140, CHE 150, CHE 171, ENVE 121. Note 1) The Humanities, Social Sciences, and Biological Science elective options are included in Appendix C & D. 2) CHE 160A, CHE 160B, CHE 160C have been increased to 3 credit hours each starting Fall 2006, to better reflect student workload.

TABLE I-1 (Continued)
BASIC-LEVEL PROGRAM
Chemical Engineering (Bioengineering Option)

Year; Semester or or Quarter	Course (Department, Number, Title)	Category (Credit Hours): Math & Basic Science	Advanced Chemistry	Engineering Topics: Engrg Science	Engrg Design (✓)	Hum. & Soc. Sci.	Other
1; Fall	MATH 9A – First Year Calculus	4					
	CHEM 1A – General Chemistry	4					
	CEE 11 – Intro to Bioengineering			2	(✓)		
	ENGL 1A – Beginning Composition					4	
1; Winter	MATH 9B – First Year Calculus	4					
	CHEM 1B – General Chemistry	4					
	PHYS 40A – General Physics	5					
	ENGL 1B – Intermediate Composition					4	
1; Spring	MATH 9C – First Year Calculus	4					
	CHEM 1C – General Chemistry	4					
	PHYS 40B – General Physics	5					
	ENGL 1C – Applied Intermediate Composition					4	
2; Fall	MATH 46 – Intro. to Ordinary Diff. Equations	4					
	CHEM 112A –Organic Chemistry		4				
	CHE 110A – Chemical Process Analysis			3			
	PHYS 40C – General Physics	5					
2; Winter	MATH 10A – Calculus of Several Variables	4					
	CHEM 112B – Organic Chemistry		4				
	CHE 110B – Chemical Process Analysis			3	(✓)		
	BIOL 5A/LA – Intro to Cell & Molecular Biology	4					
2; Spring	MATH 10B – Calculus of Several Variables	4					
	CHEM 112C – Organic Chemistry		4				
	CS 10 – C++ Programming			4			
	BIOL 5B – Intro to Organismal Biology	4					

(continued on following page)

TABLE I-1 (Continued)
BASIC-LEVEL PROGRAM
Chemical Engineering (Bioengineering Option)

Year; Semester or Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics: Engrg Science	Engineering Topics: Engrg Design (✓)	Humanities & Social Sciences	Other
3; Fall	CHE 114 – Fluid Mechanics			4	(✓)		
	ENGR 118 – Engineering Modeling			5	(✓)		
	BCH 110A – General Biochemistry		4				
	BIOL 5C – Introductory Evolution and Ecology	4					
3; Winter	CHE 100 – Engineering Thermodynamics			4	(✓)		
	CHE 120 – Mass Transfer			4	(✓)		
	BCH 110B – General Biochemistry		4				
	General Elective – H&SS					4	
3; Spring	CHE 116 – Heat Transfer			4	(✓)		
	CHE 130 – Advanced Thermodynamics			4	(✓)		
	CHE 160A – Chem. & Envi. Engineering Lab			2	(✓)		
	CHE 122 – Chemical Engineering Kinetics			4	(✓)		
4; Fall	CHE 117 – Separation Processes			4	(✓)		
	CHE 160B – Chemical Engineering Lab			2	(✓)		
	Technical Elective*			4	(✓)		
	General Elective - H&SS					4	
	General Elective - H&SS					4	
4; Winter	CHE 175A – Senior Design Project			4	(✓)		
	CHE 160C – Chemical Engineering Lab			2	(✓)		
	CHE 118 – Process Dynamics and Control			4	(✓)		
	CEE 158 – Professional Development for Engineers			3			
	Technical Elective*			4	(✓)		
4; Spring	CHE 175B – Senior Design Project			4	(✓)		
	Technical Elective*			4	(✓)		
	General Elective - H&SS					4	
	General Elective - H&SS					4	
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		63	20	78		32	
OVERALL TOTAL FOR DEGREE (EQUIV. SEMESTER CREDITS)		42.0	13.3	52		21.3	
PERCENT OF TOTAL (193 quarter hours for degree)		21.8	6.9	26.9		11.1	
Must satisfy one set	Minimum semester credit hours	32		48			
	Minimum percentage	25		37.5			

* The technical electives for the Bioengineering Option include BIEN 140A/CEE 140A, BIEN 140B/CEE 140B, BIOL 107A, BIOL 107B, BIOL 115, BIOL 121, BIOL 128 128, CEE 147, CEE 159, CHE 124, CHE 140, CHE 150. Note 1) The Humanities, Social Sciences, and Biological Science elective options are included in Appendix C & D. 2) CHE 160A, CHE 160B, CHE 160C have been increased to 3 credit hours each starting Fall 2006, to better reflect student workload.

BASIC-LEVEL PROGRAM

Chemical Engineering (Chemical Engineering Option)

Year; Semester or or Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics		Hum. & Soc. Sci.	Other
				Engrg Science	Engrg Design (✓)		
1; Fall	MATH 9A – First Year Calculus	4					
	CHEM 1A – General Chemistry	4					
	CEE 10 – Intro to CHE/ENVE Engineering			2	(✓)		
	ENGL 1A – Beginning Composition					4	
1; Winter	MATH 9B – First Year Calculus	4					
	CHEM 1B – General Chemistry	4					
	PHYS 40A – General Physics	5					
	ENGL 1B – Intermediate Composition					4	
1; Spring	MATH 9C – First Year Calculus	4					
	CHEM 1C – General Chemistry	4					
	PHYS 40B – General Physics	5					
	ENGL 1C – Applied Intermediate Composition					4	
2; Fall	MATH 46 – Intro. to Ordinary Diff. Equations	4					
	CHEM 112A –Organic Chemistry		4				
	CHE 110A – Chemical Process Analysis			3			
	PHYS 40C – General Physics	5					
2; Winter	MATH 10A – Calculus of Several Variables	4					
	CHEM 112B – Organic Chemistry		4				
	CHE 110B – Chemical Process Analysis			3	(✓)		
	BIOL 5A/LA – Intro to Cell & Molecular Biology	4					
2; Spring	MATH 10B – Calculus of Several Variables	4					
	CHEM 112C – Organic Chemistry		4				
	CS 10 – C++ Programming			4			
	CHE 122 – Chemical Engineering Kinetics			4	(✓)		

(continued on following page)

TABLE I-1 (Continued)
BASIC-LEVEL PROGRAM
Chemical Engineering (Chemical Engineering Option)

Year; Semester or Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics		Humanities & Social Sciences	Other
				Engrg Science	Engrg Design (✓)		
3; Fall	CHE 114 – Fluid Mechanics			4	(✓)		
	ENGR 118 – Engineering Modeling			5	(✓)		
	General Elective – H&SS					4	
	General Elective – H&SS					4	
3; Winter	CHE 100 – Engineering Thermodynamics			4	(✓)		
	CHE 120 – Mass Transfer			4	(✓)		
	CEE 125 – Analytical Methods for CHE/ENVE Eng.			4	(✓)		
	Technical Elective*			4	(✓)		
3; Spring	CHE 116 – Heat Transfer			4	(✓)		
	CHE 130 – Advanced Thermodynamics			4	(✓)		
	CHE 160A – Chem. & Envi. Engineering Lab			2	(✓)		
	General Elective – H&SS					4	
4; Fall	CHE 117 – Separation Processes			4	(✓)		
	CHE 160B – Chemical Engineering Lab			2	(✓)		
	Technical Elective			4	(✓)		
	General Elective – H&SS					4	
4; Winter	CHE 175A – Senior Design Project			4	(✓)		
	CHE 160C – Chemical Engineering Lab			2	(✓)		
	CHE 118 – Process Dynamics and Control			4	(✓)		
	CEE 158 – Professional Development for Engineers			3			
4; Spring	CHE 175B – Senior Design Project			4	(✓)		
	Technical Elective*			4	(✓)		
	General Elective - H&SS					4	
	General Elective - H&SS					4	
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		55	12	82		36	
OVERALL TOTAL FOR DEGREE (EQUIV. SEMESTER CREDITS)		36.7	8	54.7		24.0	
PERCENT OF TOTAL (185 quarter hours for degree)		29.7	6.5	44.3		19.5	
Must satisfy one set	Minimum semester credit hours	32		48			
	Minimum percentage	25		37.5			

* The technical electives for the Chemical Engineering Option include CEE 132, CEE 135, CHE 102, CHE 136, CHE 171, ENVE 120, ENVE 133, ENVE 134, ENVE 138 Note 1) The Humanities, Social Sciences, and Biological Science elective options are included in Appendix C & D. 2) CHE 160A, CHE 160B, CHE 160C have been increased to 3 credit hours each starting Fall 2006, to better reflect student workload.

TABLE I-2 Course/Section Summary 05F – 06S

Course No.	Title	No. of Sections offered in Current Year	Avg. Section Enrollment	Type of Class			
				Lecture	Lab.	Recit.	Other
CEE 010	Introduction to Chemical Engineering	2	33	X			
CEE 010	Introduction to Chemical Engineering	3	16		X		
CEE 011	Introduction to Bioengineering	2	11	X			
CEE 011	Introduction to Bioengineering	3	7		X		
CEE 125	Analysis Methods for Chem and ENVE Engineers	14	14	X	X		
CEE 135	Chemistry of Materials	1	9	X		X	
CEE 158	Professional Development for Engineers	27	27	X			
CHE 100	Engineering Thermodynamics	1	37	X		X	
CHE 102[#]	Catalytic Reaction Eng.	1	9	X		X	
CHE 110A	Chemical Process Analysis	1	32	X			
CHE 110A	Chemical Process Analysis	2	16			X	
CHE 110B	Chemical Process Analysis	1	25	X		X	
CHE 114	Applied Fluid Mechanics	1	29	X		X	
CHE 116	Heat Transfer	1	25	X		X	
CHE 117	Separation Processes	1	11	X		X	
CHE 118	Process Dynamics and Control	1	11	X		X	
CHE 120	Mass Transfer	1	23	X		X	
CHE 122	Chemical Eng. Kinetics	1	30	X		X	
CHE 124[#]	Biochemical Eng. Principles	1	8	X		X	
CHE 124L[#]	Biochemical Eng. Lab	1	4		X		
CHE 130	Advanced Engineering Thermodynamics	1	29	X		X	
CHE 136[#]	Advanced Topics in Heat Transfer						
CHE 140[*]	Cell Engineering						
CHE 150[*]	Biosensors						
CHE/ENVE 160A	Chemical & Environmental Engineering Lab	1	17		X		
CHE 160B	Chemical Engineering Lab	1	12		X		
CHE 160C	Chemical Engineering Lab	1	13		X		
CHE 171[#]	Pollution Control for Chemical Engineers						
CHE 175A	Chem. Processes Design I	1	13	X	X		Consultation
CHE 175B	Chem. Processes Design II						
CHE 190	Special Studies	8	1.4				Individual study under faculty supervision

ENGR 118	Engineering Modeling & Analysis	1	21	X		X	
ENVE 120#	Unit Operations & Processing-Environmental Engineering	1	12	X		X	
ENVE 121#	Biological Unit Processes	1					
ENVE 133#	Fundamentals of Air Pollution Engineering	1					
ENVE 134#	Technology of Air Pollution Engineering	1					
ENVE 138#	Combustion Engineering	1					

* Course not offered in the 05-06 Academic Year; # Technical elective

Table I-3. Faculty Workload Summary
Environmental Engineering 2005-06

Faculty Member (Name)	FT or PT (%)	Classes Taught (Course No./Credit Hrs.) 2005-2006 F-Fall 2005, W-Winter 2006, S-Spring 2006	Total Activity Distribution[2]		
			Teaching	Research	Other[3]
Wilfred Chen	FT	F-CHE 110A/3, W-CHE 100/4	25%	50%	25% Graduate adviser
David Cocker	FT	F-CEE 233/4, W-ENVE 133/4	25%	50%	25% Time release for ABET in 06
Marc Deshusses	FT	F-CHE 117/4, W-CHE 120/4	25%	30%	55% Dept. Chair
Robert Haddon	FT	S-CEE 135/4	12%	50%	38% Chemistry, split appointment
Kenneth Kauffman	FT	F-ENGR 118/5, CEE 200/4, W-CEE 158/3, CEE 118/4, S-CEE 204/4	70%	30%	0%
Mark Matsumoto	FT	W-CEE 241/4	12%	20%	68% Assoc. Dean
Ashok Mulchandani	FT	F-CHE 124/4, W-CHE 124L/2, S-CHE 116/4	35%	50%	15%
Nosang Myung	FT	F-CHE 114/4, W-CHE 110B/3, S-CHE/ENVE 160A/2	35%	50%	15%
Joseph Norbeck	FT	None	0%	30%	70% Director Environ. Res. Inst.
Jerome Schultz	FT	F-CHE 160B/2, F-ENVE 160B/2 W-CHE 160C/2	25%	20%	55% Director Bioengineering
Sharon Walker	FT	F-ENVE 171/4, W-ENVE 142/4, S-CEE 225/4	35%	50%	15%
Charles Wyman	FT	W-CEE 202/4, S-CHE -122	25%	60%	15%
Jianzhong Wu	FT	F-CEE 206/4, S-CHE/ENVE 130/4	25%	50%	25% Graduate adviser
Yushan Yan	FT	F-CHE 102/4	12%	40%	48% Time release for ABET in 06; family sick leave W

Table I-3. (continued) Faculty Workload Summary
Environmental Engineering 2005-06

Lecturers					
Kawai Tam	PT	F-CEE 10/11(4), ENVE 120/4, W-CEE 10/11(4), CHE 175A/4 ENVE 175A/4, S-CHE 175B/4, ENVE 175B/4, CEE 132/4, CEE 232/4	60-80%		Lecturer
Sang-Mi Lee	PT	S-ENVE 134/4	12%		Postdoctoral researcher
Wayne Miller	PT	W-ENVE 160C/2	12%		Adjunct professor
Tom Perina	PT	W-ENVE 135/4	12%		CH2MHill employee
Kwangsa Na	PT	W-CEE 125/4	12%		Postdoctoral researcher
Sam Abi-Samra	PT	S-ENVE146/4	12%		CDM employee
Henry Sheng	PT	No teaching in 2006, will teach CHE 171 in 06-07	0%		Consultant

Table I-4. Faculty Analysis
Department of Chemical and Environmental Engineering

Name	Rank	FT or PT	Highest Degree	Institution from which Highest Degree Earned & Year	Years of Experience			State in which Registered	Level of Activity (high, med, low, none)		
					Govt./ Industry Practice	Total Faculty	This Institution		Profession-al Society	Research	Consulting/ Summer Work in Industry
Chen, Wilfred	Prof	F	Ph.D.	Caltech 1993	0	12	12	-	AIChE, ACS, ASM	High	None
Cocker, David	Assoc	F	Ph.D.	Caltech 2001	0	5	5	EIT CA	AAAR, AWMA	High	None
Deshusses, Marc	Prof	F	Ph.D.	Swiss Fed Inst. Tech 1994	0	12	12	-	AIChE, ACS, AWMA	High	Med
Haddon, Robert	Dist. Prof.	F	Ph.D.	Penn State 1971	>20	12	6	-	ACS,MRS, APS,AAAS, RSC	High	Med
Kauffman, Kenneth	Asst	F	Ph.D.	U. Delaware 2003	0	1	1	EIT IA	AIChE, ACS, ASME, NSTA, ASEE	Med	None
Matsumoto, Mark	Prof	F	Ph.D.	UC Davis 1982	0	23	12	EIT CA	AAAS, CWEA, WEF	Med	None
Mulchandani, Ashok	Prof	F	Ph.D.	McGill U 1985	6	16	15	-	AIChE, ACS, AAAS	High	None
Myung, Nosang	Asst	F	Ph.D.	UCLA 1998	3	3	3	-	AIChE, ACS, ECS	High	None
Norbeck, Joseph	Prof	F	Ph.D.	U Nebraska 1974	15	14	14	-	ACS, AAAS, AWMA, SAE	Med	Med
Jerome Schultz	Prof	F	Ph.D.	U Wisconsin 1958	8	40	3	-	AIChE, ACS, BMES, ASAIO, AAAS, NAE	Med	Low

(see list of abbreviations for professional societies 2 pages below)

Name	Rank	FT or PT	Highest Degree	Institution from which Highest Degree Earned & Year	Years of Experience: Govt./ Industry Practice	Years of Experience: Total Faculty	Years of Experience: This Institution	State in which Registered	Level of Activity (high, med, low, none): Professional Society (Indicate Society)	Level of Activity (high, med, low, none): Research	Level of Activity (high, med, low, none): Consulting/ Summer Work in Industry
Faculty (cont.)											
Walker, Sharon	Asst	F	Ph.D.	Yale 2004	0	2	2	-	ACS, AIChE, ASM,AEESP, SWE, AWIS	High	None
Wu, Jianzhong	Assoc	F	Ph.D.	UC Berkeley 1998	2	6	6	-	AIChE, ACS, IACT	High	None
Wyman, Charles	Prof	F	Ph.D.	Princeton 1971	23	12	1	-	AIChE, ACS, BERA - Med	High	Med
Yan, Yushan	Prof	F	Ph.D.	Caltech 1997	3	8	8	-	AIChE, ACS, MRS, ECS, NAMS, IZA	High	Med
Lecturers											
Kawai Tam	Lect	PT	Ph.D.	McGill 2002	2	8	8		-	-	-
Sang-Mi Lee	Lect	PT	Ph.D.	Seoul Nat. U. 1999	3	5	2		-	-	-
Wayne Miller	Adj Prof	PT	Ph.D.	Caltech, 1976	>20	6	6		-	-	-
Tom Perina	Lect	PT	Ph.D.	UCR 2003	>10	2	2	CA (Geol+ Hydrogeol)	-	-	-
Kwangsa Na	Lect	PT	Ph.D.	Yonsei U. Seoul 2001	0	1	1		-	-	-
Sam Abi-Samra	Lect	PT	M.S.	U. Kansas	>20	1	1	CA	-	-	-
Henry Sheng	Lect	PT	Ph.D.	U Oklahoma 1968	>5	>30	10	CA, OH	-	-	-

(see list of abbreviations for professional societies one page below)

Abbreviations for Professional Societies listed in Table I-4

AAAR	American Association for Aerosol Research AAAS American Association for the Advancement of Science
ACS	American Chemical Society
AEESP	Association of Environmental Engineering and Science Professors
AIChE	American Institute of Chemical Engineers
APS	American Physical Society
ASAIO	American Society for Artificial Internal Organs
ASEE	American Society for Engineering Education
ASM	American Society for Microbiology
ASME	American Society Of Mechanical Engineers
AWIS	Association for Women in Science
AWMA	Air and Waste Management Association
BMES	Biomedical Engineering Society
CWEA	California Water Environment Association
ECS	Electrochemical Society
IACT	International Association of Chemical Thermodynamics
IZA	International Zeolite Association
MRS	Materials Research Society
NAMS	North American Membranes Society
NAE	National Academy of Engineering
NSTA	National Science Teachers Association
RSC	Royal Society of Chemistry
SAE	Society of Automotive Engineers
SWE	Society of Women Engineers
WEF	Water Environment Federation

Table I-5. Support Expenditures

Bourns College of Engineering - Chemical & Environmental Engineering

	1	2	3	4
	2004	2005	2006	2007
Fiscal Year	(prior to previous year)	(previous year)	(current year)	(year of visit)
Expenditure Category				
Operations (not including staff)	205,800	279,088	317,737	
Travel	25,674	47,952	62,607	
Equipment				
Institutional Funds	196,235	136,775	159,589	
Grants and Gifts	66,222	27,345	16,066	
Graduate Teaching Assistants	146,946	137,752	184,088	
Part-time Assistance (other than teaching)	14,973	21,845	43,352	