BOURNS COLLEGE OF

Engineering

Self-Study Report

Environmental Engineering

Submitted by:
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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 Environmental Engineering Program following the Fall 2000 visit appears below. Note that the previous ABET review was conducted under the "old" criteria.

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Environmental Engineering
Program

Introduction

The environmentai engineering program provides an educationai experience in many traditionai areas supported by a strong background in chemical engineering areas.

Program Strengths

1. The program faculty members, as well as adjunct faculty members, are well qualified and engaged with students. Nearly all, including the adjunct faculty members, are active in research and are publishing in respected journals.

2. The current academic program, the result of substantial change from what existed several years ago, provides a very good educational experience for its students.

Program Concerns

1. Criterion I.C.2. Curriculum Objectives The articulation of environmental engineering program goals to the public through catalog statements and other media is not being accomplished.

   - Due process response: The program now has a web page that presents the program's goals, objectives, and the way they are achieved in the educational program.

   - No mention was made regarding the publication of these statements in the university catalog or college publication.

   - This weakness has been resolved due to webpage publication. However, it remains a concern pending publication of the appropriate statements in catalogs and other publications available to the public.

2. Criterion I.C.1. Faculty This criterion requires that there be not less that three full-time-equivalent faculty members in a program (see Criterion I.C.1.c.). The environmental

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engineering faculty has about 3.25. The EAC is concerned that the growth of the full-time graduate program will draw faculty resources from the undergraduate program. The program must be vigilant to meet the need for a minimum of three full-time faculty member equivalents for the undergraduate program.

- Due process response: The program has hired one additional faculty member bringing the number to about 4.5 FTEs.
- This concern has been resolved.

3. Criterion I.C.6 Facilities This criterion requires a program to have a carefully constructed and functioning plan for the continued replacement, modernization and maintenance of laboratory equipment (see Criterion I.C.6.d.). The program has some of the elements of a lab plan, but it is incomplete. These and the other elements of such a plan should be brought together in a coherent document.
   - Due process response: The program has provided an adequate, detailed presentation of the laboratory equipment holdings, purchase and replacements dates, and costs for the next five years.
   - This concern has been resolved.
4. Criterion II.L.3 Program Criteria, Curriculum This criterion requires that system and facility operation and maintenance be stressed in design courses. This criterion does not appear to be thoroughly addressed. More faculty attention to this aspect of design is needed.
   - Due process response: The response presents the EAC with more details on the actual amount of system and facility operation and maintenance material in the curriculum than was made available at the time of the visit. The response also indicated that this will be a continuing issue in the teaching program.
   - This concern has been resolved.

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Program Observation

1. Students from this program who enter professional environmental engineering practice will find it difficult to practice successfully unless they become Registered Professional Engineers. It is suggested that the program's faculty needs to stress this more to its students and to serve as role models for them to emulate.

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, as well as in the printed and on-line versions of UCR's General Catalog. Regarding the size of the environmental engineering faculty, the department currently has 11.5 FTEs (not counting the FTEs of faculty who are moving to Bioengineering), of which 4 concentrate on environmental engineering. We are in the process of hiring several new faculty, and we are hopeful that at least one will be in environmental engineering. Further, leveraging of FTE resources is accomplished by cross-listing of courses between the chemical and environmental engineering programs. The support and resources for purchasing and maintenance of instructional equipment are presented in Section B.7.

Criterion II.L.3, "System and facility operation and maintenance," was identified as a possible continuing issue in the teaching program. System and facility operation and maintenance is taught in the senior design course (ENVE 175AB) and in some technical electives. However, since 2000, the Criterion II.L.3 has been dropped and therefore the relative importance of the potential issue has been lessened.

Regarding the observation on professional registration, the importance of professional registration is stressed in CEE 158: Professional Development for Engineers, a required 3 unit course for environmental engineering students which focuses on the preparation for the FE exam and stresses professional development. PE registration among Chemical and Environmental Engineering (CEE) instructors has improved: two lecturers in the Department of Chemical and Environmental Engineering are registered PE, one is a registered geologist and hydrologist, and three faculty are EIT.

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 Colleges' 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.

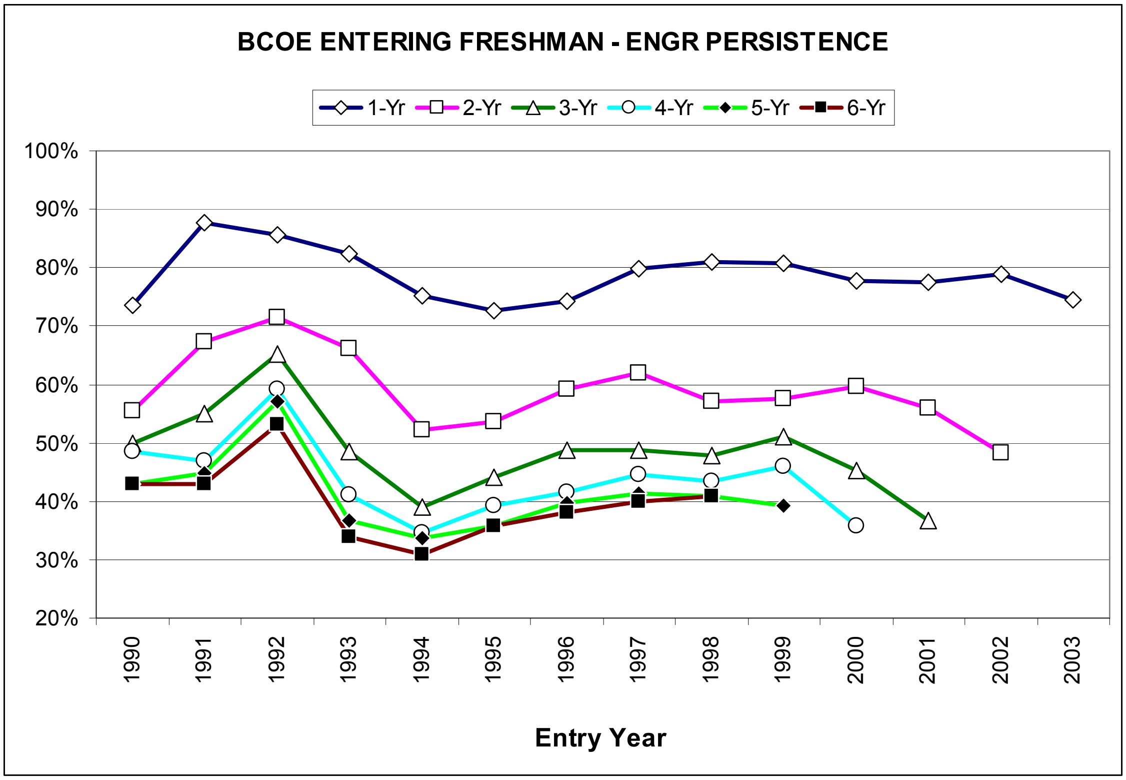

Figure 1. Persistence of entering freshmen in the Bourns College of Engineering.

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.

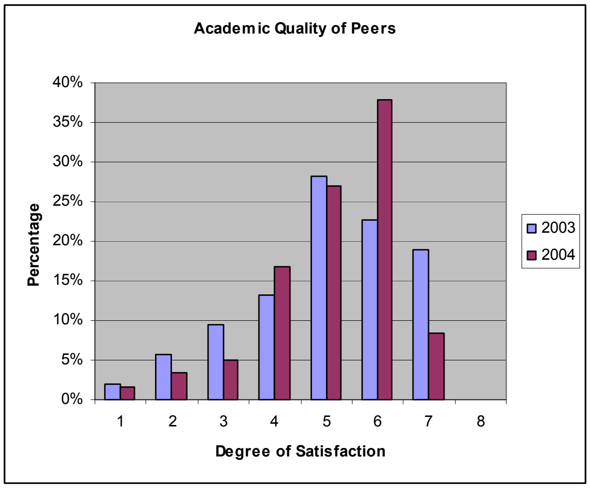

Figure 2. Student assessment of academic quality of peers.

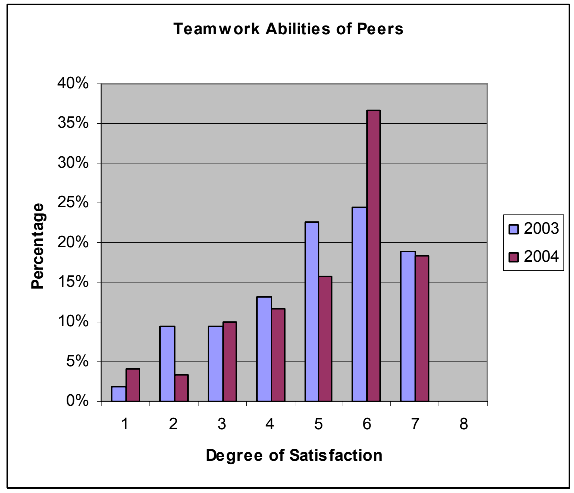

Figure 3. Student assessment of teamwork abilities of peers.

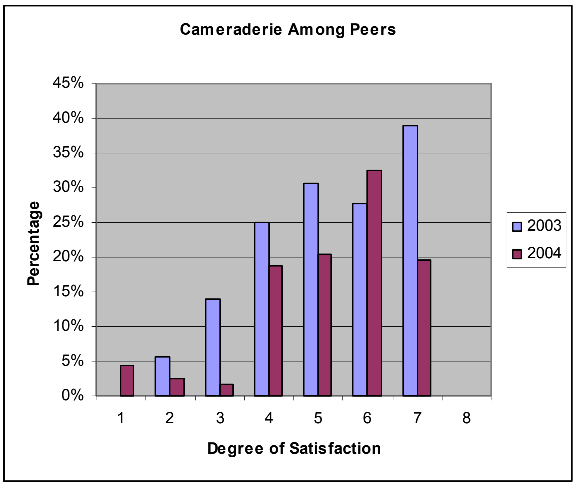

Figure 4. Student assessment of peer camaraderie.

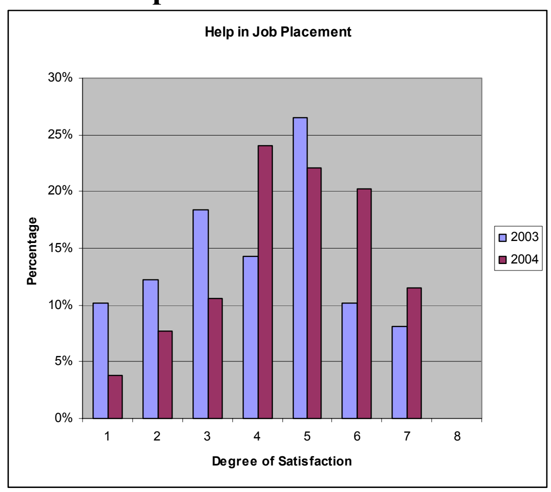

Figure 5. Student assessment of the College's helpfulness in job placement.

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.

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 CHASS, 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, 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.

A 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.1.1 to B.1.3.

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 Freshman 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 (e-mail, 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 Mentor as a condition of registration every quarter of their first year of enrollment.

Instructions for meeting with Faculty Mentors and contact information is provide via e-mail, posted on the College of Engineering Office of Student Academic Affairs' website and 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, hard-copy 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.

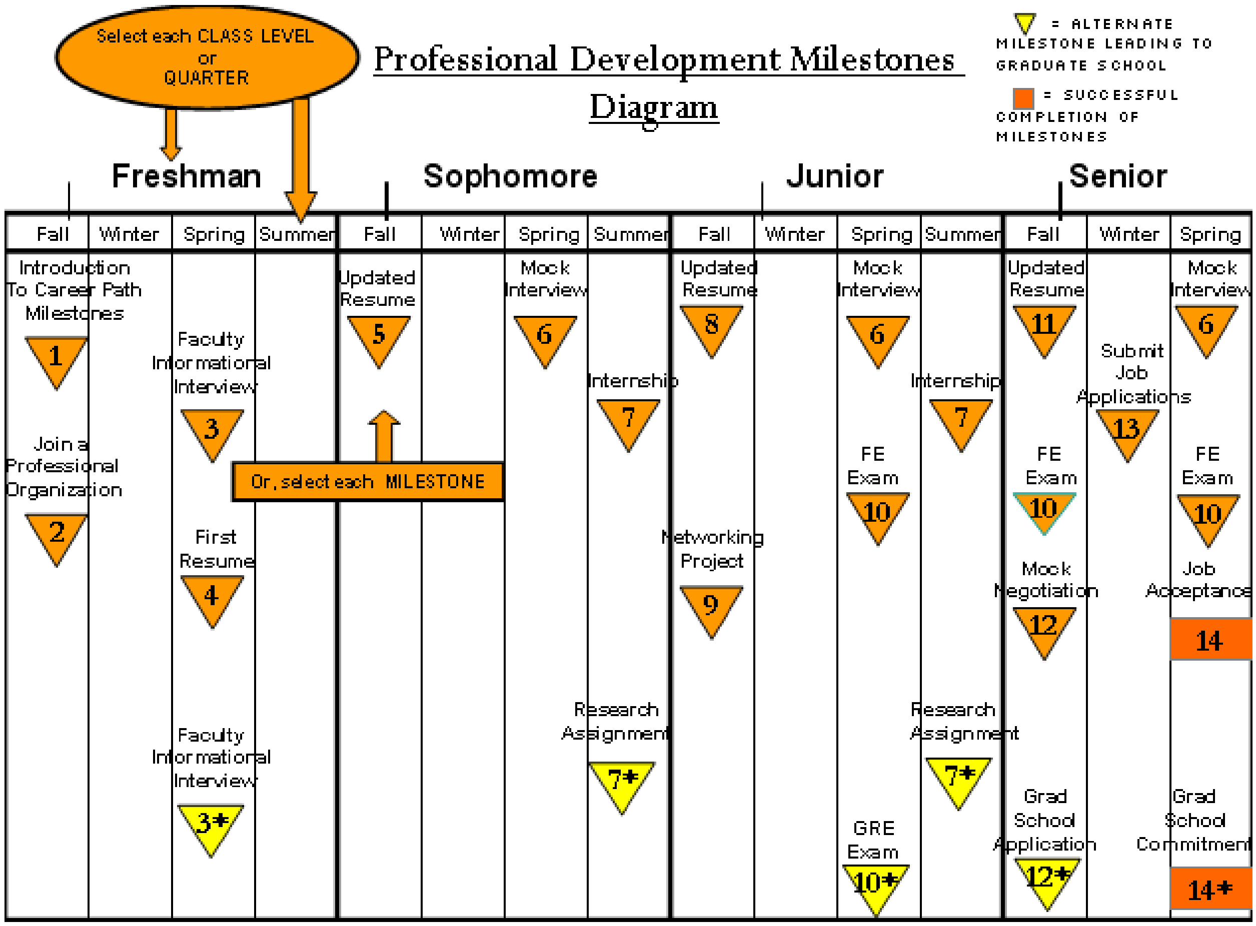

Figure 6. Diagram of key points during an undergraduate's tenure at which the Professional Development Milestones program prompts the student to take action in preparation for internships and academic or industrial career opportunities.

B.2 Program Educational Objectives

This section describes the Environmental 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 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 life long 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/env.shtml) of our environmental engineering program are to produce graduates who:

1. demonstrate the ability to apply mathematics, engineering principles, computer skills, and natural sciences to environmental 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 environmental engineering that involve air quality systems evaluation and engineering, air pollution control technology, water quality systems evaluation and engineering, water and wastewater treatment, or site remediation,
4. are prepared to pursue graduate education and research in environmental 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 pre-eminence 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 pre-eminent 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 ENVE program is unusual in that its orientation is closer to a chemical engineering curriculum than to a civil engineering curriculum, as is often the case at other institutions. This provides our students with a fundamental background in air and water pollution with detailed training in chemistry, biology, chemical thermodynamics, chemical kinetics, chemical transport, and unit operations to complement specific courses focused on water and air quality control engineering. In turn, this provides students with excellent training and adaptive skills for changing processes in air and water control engineering. The components of the mission of the Bourns College of Engineering most relevant to the undergraduate program in Environmental 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 Environmental 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 environmental 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 ENVE 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 and 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 Environmental 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 about 20 members from both 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 advise 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	Pacific Fuel Cell Corp. (Chairman of the Board)
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 ENVE 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.

Environmental Engineering deals with design and construction of processes and equipment intended to lessen the impact of man's activities on the environment. With the growing importance of environmental quality, the environmental engineer plays a pivotal role in modern industrial activity. Environmental engineers are involved in a wide range of activities including the design of alternative fueled vehicles, the development of renewable energy sources, the design of equipment for solid waste collection and disposal, municipal and industrial wastewater treatment, air pollution control systems, and hazardous waste management. At UCR, the B.S. degree in Environmental Engineering allows students to concentrate on air and/or water quality. 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 environmental 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 ENVE 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/env.shtml). The 2003 changes were motivated by several factors which included the exit comments from the 2000 ABET review, a complete review of the environmental 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 environmental engineering program are to produce graduates who:

1. demonstrate the ability to apply mathematics, engineering principles, computer skills, and natural sciences to environmental 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 environmental engineering that involve air quality systems evaluation and engineering, air pollution control technology, water

quality systems evaluation and engineering, water and wastewater treatment, or site remediation,
4. are prepared to pursue graduate education and research in environmental 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 ENVE alumni pool.

A part of this survey asked the alumni to evaluate the relevance of the six ENVE educational objectives. Figure 7 summarizes of the responses to each objective. It appears that there is good general buy-in of the ENVE program objectives (average scores of 4.18 (objective #5) to 4.91 (objective #1)) although clearly a larger response would be desirable for a strong statistical analysis of the data.

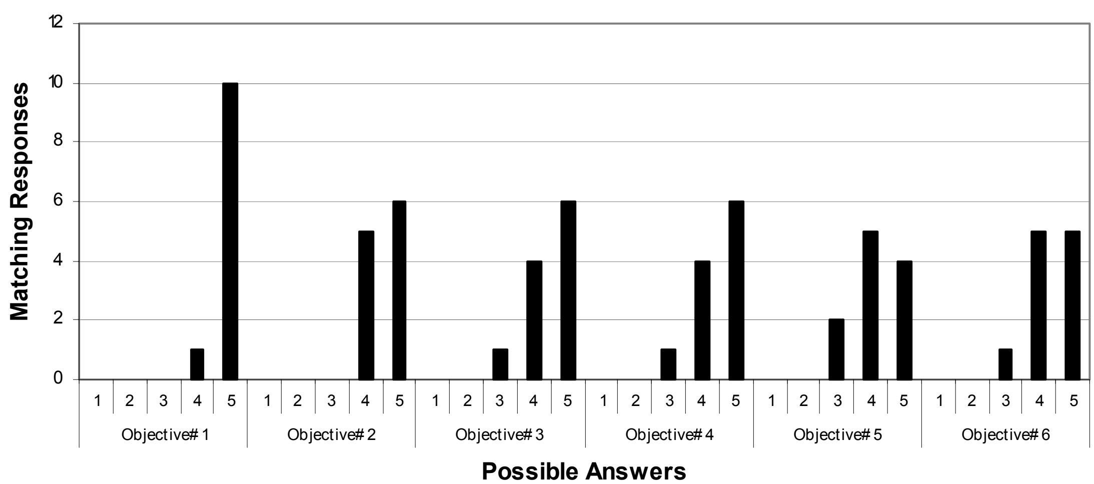

Figure 7. Alumni survey response on the relevance of the six ENVE objectives. (See above for the complete wording of the objectives.) 1=not relevant; 5=highly relevant objective.

Clearly the alumni agree most strongly with objective #1. After discussion among the ABET committee, it was hypothesized that the slightly lower responses from several alumni likely reflected their view of how well we had met these objectives as opposed to how relevant they were (for instance, objective #5 scored lower on both their relevance scores as well as the alumni's opinion of their achievement within the program as seen in B.2.5). This hypothesis appears to be validated by the strong correlation between the relevance of the objectives as stated by the alumni and their beliefs that these objectives have been met. An informal discussion with some of the alumni who did respond to the survey also supported this assertion. Irregardless, the faculty is confident that there is broad support of the six ENVE objectives.

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

A detailed curriculum is presented in Appendix I. The Environmental 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 environmental 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 and written and oral communication.
- Use of computer simulation and modeling in the solution of problems and in design.
- Application of knowledge to design problems common to modern environmental 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 two emphases (water and air), 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 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 environmental 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), Physics (PHYS 040A, PHYS 040B, PHYS 040C), and Biology (BIOL 005A, BIOL 05LA), students acquire skills in environmental engineering sciences (including air (ENVE 133), water (ENVE 142) and soil sciences (ENSC 100/100L) transport phenomena (CHE 114, CHE 120, and ENVE 135), thermodynamics (CEE100 and CEE130), mass balances (ENVE 171), unit operations (ENVE 120), engineering modeling (ENGR 118), and design (numerous courses). Additional technical electives differentiate the water and air options with both options building a core foundation for their specific emphasis. These are reinforced through two major laboratories focused on data acquisition and advanced experimentation (ENVE 160 series and CEE 125). The program culminates in a capstone senior design project (ENVE 175 AB) 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), 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 ENVE 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. Almost every course in the ENVE curriculum has one or several associated mini-design projects that require the students to synthesize the engineering principles covered in the course to address current environmental engineering concerns under constraints identified within the design problem (often laid out by the students themselves). For example, ENVE 120 this year required students to identify a mix of chemical pollutants (such as from a damaged petroleum refining plant) likely present in the floodwaters from Hurricane Katrina and identify possible clean-up strategies. The students were asked to discuss the economic (as well as time constrained) viability of these strategies. The strategy of pumping all the polluted water back into Lake Pontchartrain was then discussed in the class in light of the findings of their in-class design project. Similar current design projects are prevalent throughout the ENVE curricula. 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 environmental engineering that involve air quality systems evaluation and engineering, air pollution control technology, water quality systems evaluation and engineering, water and wastewater treatment, or site remediation,*

Science and engineering courses discussed in the context of objectives #1 and #2 provide students with disciplinary intellectual rigor required to succeed in industry. The ability to formulate problems, make and test assumptions, predict and solve problems enable students to succeed in the field environmental engineering. Fundamental problem solving skills developed throughout the curricula are then applied to all ENVE students in both water and air quality systems engineering applications. The air or water option student then further pursues the emphasis through three additional technical elective courses. The laboratory courses (ENVE 160ABC) offered ensure that the student is trained for laboratory and field work within their discipline while the capstone senior design project is designed to emulate problems that will be encountered within the students career.

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

The technical rigor required to pursue advanced graduate degrees in environmental engineering and other related fields is emphasized in our basic curriculum. Additionally, the ENVE 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 ENVE 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 ENVE undergraduate students conducting research either as paid research assistant, summer trainees, or volunteers in the CEE department. An estimate is that about 80% of the ENVE 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.

***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 and ENVE 171), the professional development course (CEE 158), and the senior design project (ENVE 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 are broadly covered in the upper division ENVE 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 who 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). In subsequent quarters, students are required to work in teams (Laboratory courses ENVE 160ABC, numerous course specific team mini-design projects [e.g., ENVE 133, ENVE 142], and Senior Design courses ENVE 175 A/B). Other examples include team problem solving in the classroom (e.g., routinely in CHE 120 Mass Transfer). The program culminates with a significant team project undertaken by students as part of the senior design sequence (ENVE 175A/B) in the final year.

The majority of the upper-division engineering courses in the Environmental 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. All instructors provide students with guidelines 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), in senior design (ENVE 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, 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. For example, this year, all environmental engineering seniors attended a California Water Environment Association (CWEA) meeting (funding for attending this event was provided by the department), where contemporary issues were discussed. The meeting was attended by professionals, and provided an opportunity to reinforce the needs for continuous learning with the students.

B.2.5 Achievement of Program Educational Objectives and Program Review

The ENVE 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 biennially.

The current set of educational objectives were 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 <u>attainment</u> of the ENVE 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 ENVE 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.

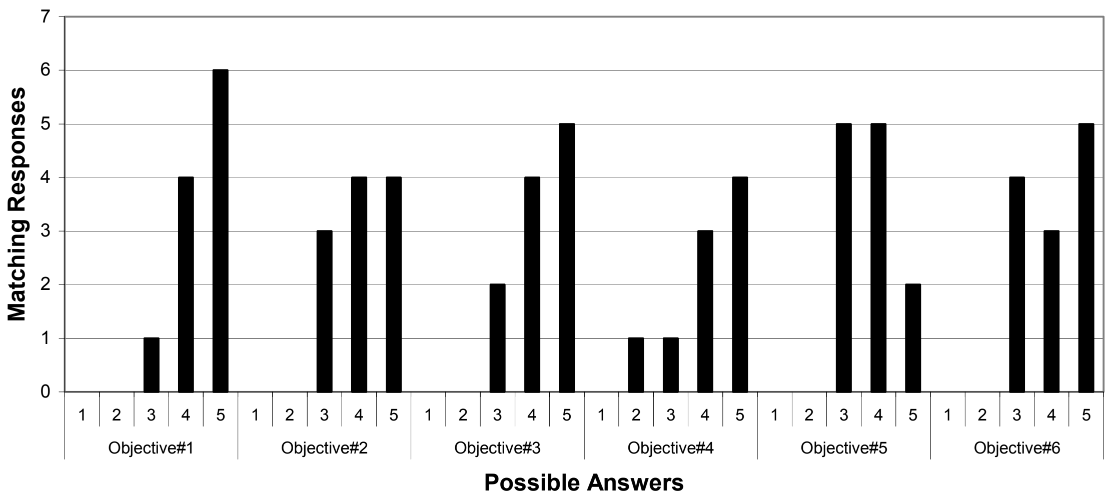

Figure 8. Alumni survey response on the <u>attainment</u> of the six ENVE objectives. (See Section B.2.3 for the complete wording of the objectives). 1=not attained; 5=Very well attained.

The poll indicates an overall positive response from the ENVE alumni with average responses for the objectives ranging from 3.75 (objective #5) to 4.45 (objective #1). 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 only objective with a score less than 4.00, was most recently addressed in the ENVE curriculum through the addition of CEE 10 and CEE 158. These courses will first be completed as required curriculum by all students the exiting class of 2006 (some but not all alumni have already graduated with the CEE 10 and 158 requirements), so the changes to the curricula are not fully apparent in the alumni survey. The ABET committee suggested continued monitoring of objective #5 to see if recent programmatic changes will have addressed this apparent shortcoming. Extensive discussions also led to the general conclusion among the ENVE faculty that while the numbers were encouraging, careful and close monitoring of all objectives was necessary as more responses were received improving the statistics of the survey.

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.

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

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.

The response rate for ENVE was disappointing with responses from only four alumni (covering the past four graduation years). However, the composite engineering alumni response, coupled with the ENVE alumni response, indicates that a significant number of students pursue higher educational degrees (objective #4) point to a desire for strong life-long learning. The ABET

Committee was very happy to see that all responding ENVE students believe 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). All 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).

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.

An employer survey was also conducted in spring 2006 to evaluate employers' assessment of ENVE student achievement of the key 6 educational objectives for ENVE. 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 18 alumni, out of 109 all time ENVE graduates. The response rate was good as responses were received from 14 ENVE alumni employers (9 in academia, 5 in industry). The results are tabulated below (Table 4). Figure 9 displays a histogram of employers ratings of ENVE alumni achievement of objectives.:

The employers of ENVE alumni appear to be generally very satisfied with their achievement of the six educational objectives with mean achievements greater than 4.3 out 5 for all six educational program objectives. Continued monitoring and survey of the UCR alumni employers will continue in the future.

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

	Mean	Stdev
Objective 1	4.71	0.47
Objective 2	4.43	0.65
Objective 3	4.43	0.65
Objective 4	4.36	0.74
Objective 5	4.64	0.50
Objective 6	4.64	0.50

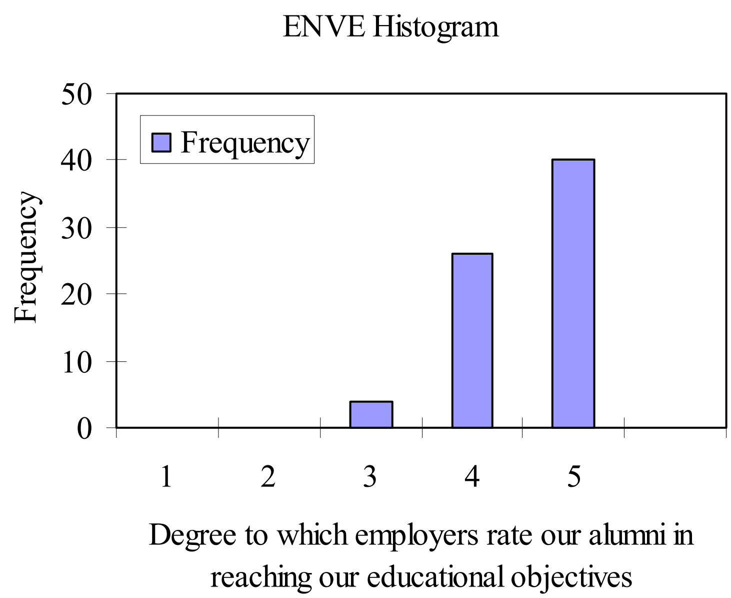

Figure 9. Employer ratings of ENVE alumni achievement of educational objectives. Since there was little difference in reaching each one of our six educational objectives, the ratings were merged to show a compounded distribution.

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 other outcome analysis assessments. Section 3.6 describes changes that we have made to the program in response to the assessments, Section 3.7 outlines changes to Freshman Chemistry, and finally Section B.3.8 identifies the materials that will be available to examiners during the site visit.

B.3.1 Program Outcomes

Graduates of the Environmental Engineering program must demonstrate:

1. Ability to apply knowledge of mathematics, science and engineering.
2. Ability to design and conduct experiments, as well as analyze and interpret data.
3. 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.
4. Ability to function on multidisciplinary teams.
5. Ability to identify, formulate, and solve engineering problems.
6. Understanding of professional and ethical responsibility.
7. Ability to communicate effectively.
8. A broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
9. Recognition of the need for and an ability to engage in lifelong learning.
10. Knowledge of contemporary issues.
11. 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 environmental 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 environmental engineering that involve air quality systems evaluation and engineering, air pollution control technology, water quality systems evaluation and engineering, water and wastewater treatment, or site remediation,

4. are prepared to pursue graduate education and research in environmental 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.

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. Outcome 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.

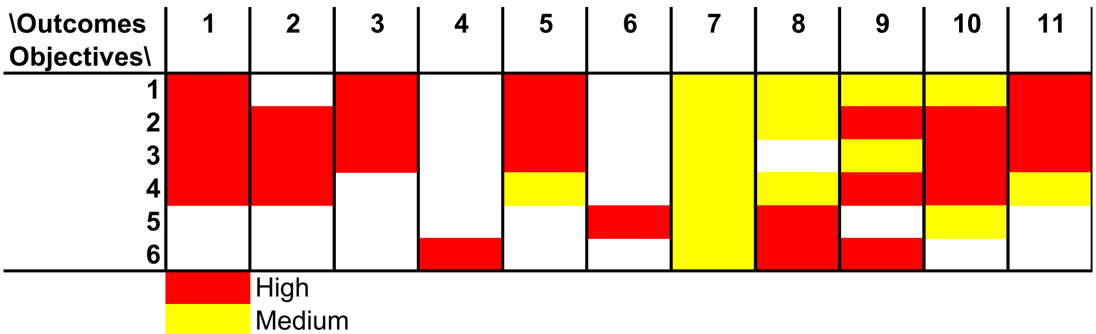

Figure 10. Correlation of our 6 educational objectives to the 11 outcomes.

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 ENVE 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 essentially identical for all programs.

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.

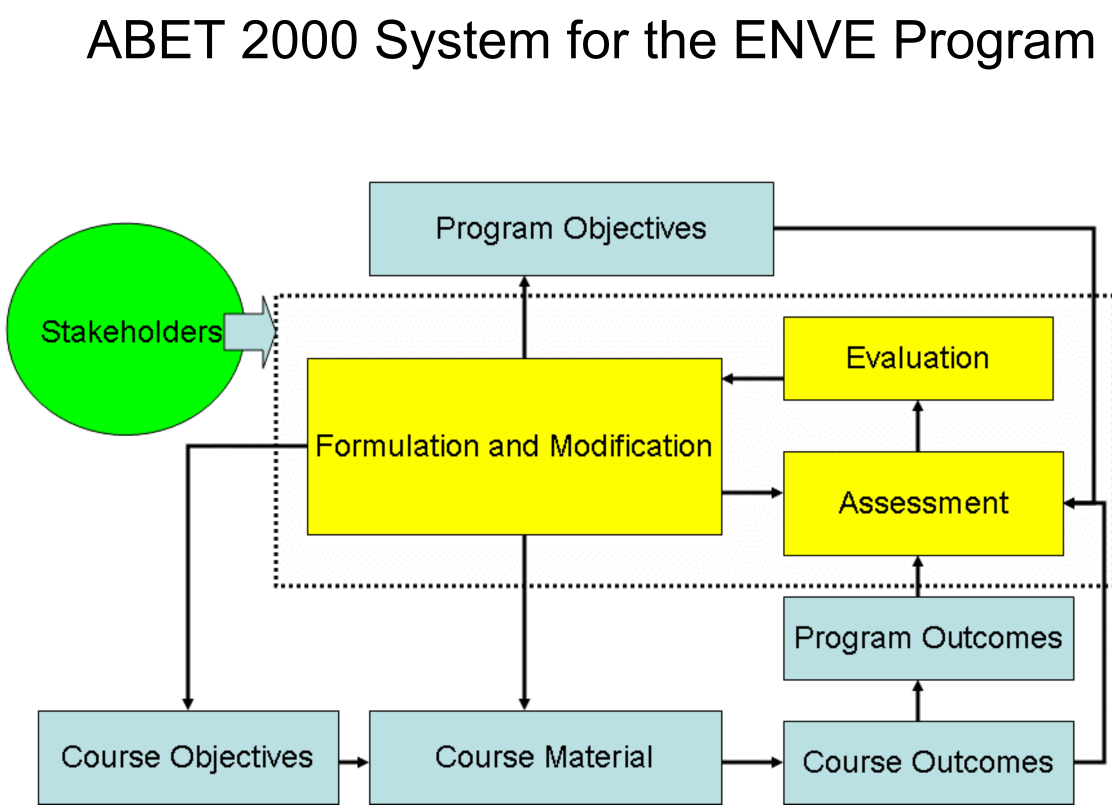

Figure 11. Environmental Engineering program system for course improvement.

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 committee, 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 committee. As an example, Figure 12 shows the assessment for all non-technical elective required (CHE, CEE and ENVE) courses required for all ENVE students.

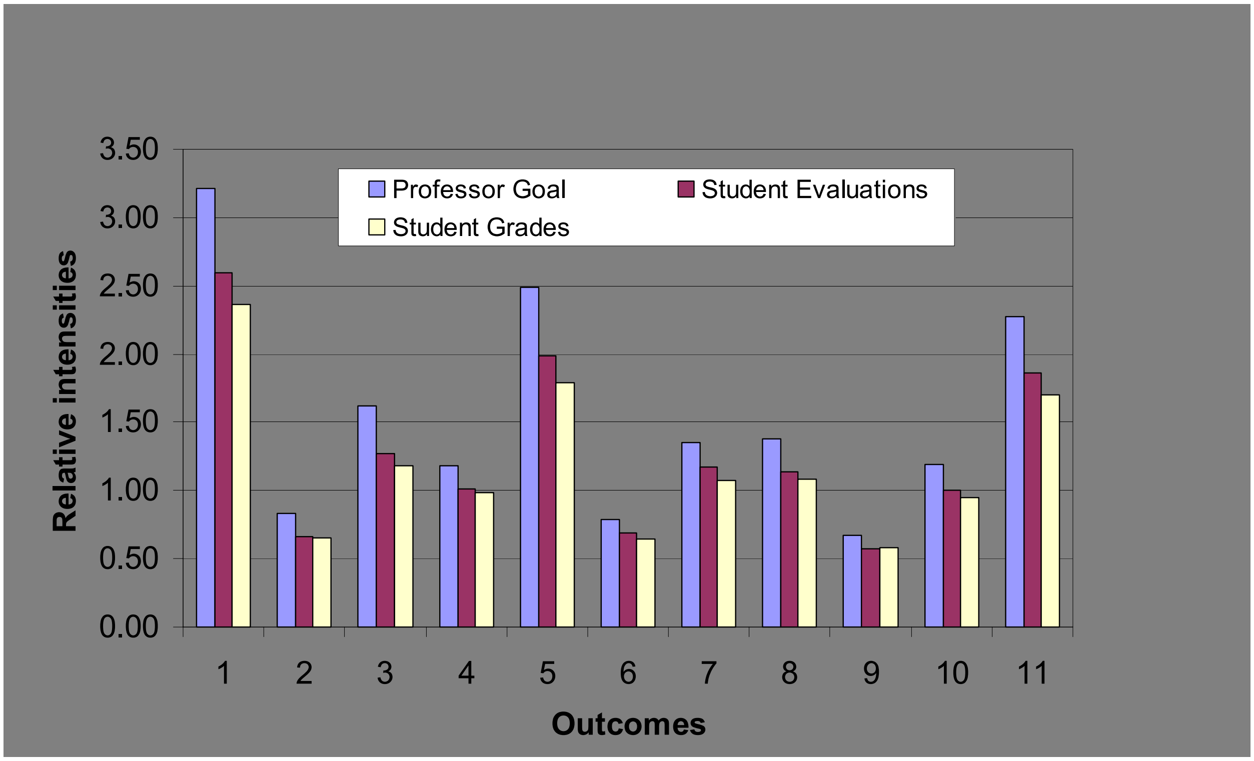

Figure 12. Example of a 2004 assessment of 1-11 (i.e., a-k) ABET outcomes. The Professor Goal represents the maximum achievable for the given outcome, the Student Evaluations are from the students surveys of the attainment of the course objectives (linked to ABET outcomes), while the Students Grades 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 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 committee with overall findings presented at the faculty retreat. The 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, 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 low number of graduates (typically fewer than 10 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 above. The alumni survey was also used to evaluate alumni support for program evaluation outcomes (as discussed later in this section).

The senior exit surveys[1] and alumni surveys provide student feedback on the overall ENVE 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 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 ENVE program with only a fraction of those surveyed having completed the ENVE 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 ENVE major.

Every course in Environmental 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 ENVE 142. 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.

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.

[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.

Item	OUTCOME-RELATED LEARNING OBJECTIVES	OUTCOMES													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Broad overview of water quality principles. Understand the fundamental issues and relevance.	3		2		1	2		3		2	2			
2	Know how water and waste water quanities and quality are estimated.	3	1	2		3					2				
3	Know how to apply numerical and graphical techniques to analyze water chemistry at equilibrium condition.	3		1		3			1						
4	Acquire basic skills in reaction kinetics, reactor design, and materials balances.	3		3		3			3	2	2				
5	Know how to use literature (graphs, tables, government documents, etc.) to estimate and select the necessary parameters for problem solving.	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 transport mechanisms (advective/dispersive, phase transfer and adsorption) in water.	1		1		1									
8	Aquire technical information judgement and communication skills (homework, exam, design project)	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: Winter 2005, ENVE 142, Water Quality Engineering.

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

$$\frac{\text{(average student survey result for objective 1)}}{3}$$

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 the course were fully achieved).

Figures 14 show results of the student survey for the ENVE example. 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., 16.8/19 for outcome 1 = 88%). 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.

	Objectives									
Student	1	2	3	4	5	6	7	8	9	10
1	3	3	3	3	3	3	3	3		
2	2	3	2	3	2	2	2	2		
3	3	3	3	2	2	3	3	3		
4	3	3	3	3	3	3	2	3		
5	3	3	2	3	2	3	2	3		
6	3	3	3	3	2	2	2	3		
7	2	2	2	2	3	2	2	2		
8	3	3	2	2	3	3	3	3		
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
Average	0.92	0.96	0.83	0.88	0.83	0.88	0.79	0.92	0.00	0.00

Figure 14. End-of-class student survey response for ENVE 142 (Winter 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	2.5	0.0	0.8	0.0	2.5	0.0	0.0	0.8	0.0	0.0	0.0
4	2.6	0.0	2.6	0.0	2.6	0.0	0.0	2.6	1.8	1.8	0.0
5	1.7	0.8	0.8	0.0	1.7	0.0	0.8	2.5	0.0	0.0	0.0
6	2.6	0.9	0.9	2.6	2.6	0.0	1.8	0.0	0.0	0.9	0.9
7	0.8	0.0	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
8	0.9	0.9	2.8	0.9	2.8	0.9	0.0	2.8	1.8	2.8	2.8
9											
10											
Subtotals	16.8	3.6	12.5	3.5	16.8	2.8	2.6	11.5	3.6	9.1	5.5
Percent	88%	90%	89%	89%	88%	92%	86%	88%	90%	91%	91%

Figure 15. Outcome evaluation of student end-of-class survey, Winter 142 (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 (1 indicates problem addresses objectives set for course)										
Problem	1	2	3	4	5	6	7	8	9	10	
1	1	1	1	1	0	0	0	0			qz1
2	1	1	0	1	0	0	0	0			qz2
3	1	1	1	1	0	0	0	0			qz3
4	1	0	1	1	1	0	1	0			qz4
5	1	1	1	1	1	0	0	0			mt1_1
6	1	0	1	1	0	0	0	0			mt1_2
7	1	0	1	1	0	0	0	0			mt1_3
8	1	1	0	1	1	0	1	0			mt1_4
9	1	1	0	1	0	0	0	0			mt2_1
10	1	0	0	1	1	1	1	1			mt2_2
11	1	1	1	1	1	1	0	0			homework
12	1	0	1	1	1	0	1	0			des
13	1	1	0	1	1	0	0	0			f1
14	1	0	1	1	0	0	0	0			f2
15	1	1	0	1	0	0	0	0			f3
16	1	1	0	1	0	0	1	0			f4
17	1	1	1	1	0	0	0	0			f5
18	1	0	1	1	1	0	0	0			f6

Figure 16. Linkage of course questions to objectives, ENVE 142 (2004-05).

	Student (grade of each of 9 students on all 18 problems)									
Problem	1	2	3	4	5	6	7	8	9	Average
1	0.75	0.65	0.75	0.75	0.70	0.65	0.85	0.75	0.85	74.44%
2	0.60	0.80	1.20	1.10	0.90	0.80	1.10	0.70	0.60	86.67%
3	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	88.89%
4	1.00	0.80	1.00	1.00	1.00	0.90	1.00	0.70	0.95	92.78%
5	0.80	0.53	0.60	0.60	0.13	0.60	0.60	0.20	0.07	45.93%
6	0.68	0.40	0.68	0.84	0.04	0.68	0.68	0.32	0.24	50.67%
7	0.37	0.40	0.66	0.31	0.29	0.17	0.74	0.29	0.46	40.95%
8	0.48	0.20	0.40	0.68	0.32	0.20	0.76	0.48	0.56	45.33%
9	0.44	0.16	0.98	0.54	0.28	0.66	0.90	0.92	0.56	60.44%
10	0.16	0.14	0.60	0.48	0.32	0.36	0.50	0.32	0.08	32.89%
11	0.68	0.61	0.76	0.65	0.62	0.71	0.83	0.66	0.57	67.65%
12	0.97	0.98	0.98	0.97	1.00	0.97	1.00	1.00	0.98	98.33%
13	0.10	0.50	0.90	0.25	0.20	0.30	0.50	0.05	0.25	33.89%
14	0.05	0.00	0.20	0.30	0.10	0.35	0.20	0.10	0.40	18.89%
15	0.1	0.20	0.30	0.40	0.10	0.30	0.30	0.10	0.35	23.89%
16	0.45	0.40	0.65	0.35	0.40	0.40	0.55	0.60	0.50	47.78%
17	0.00	0.65	0.50	1.00	0.00	0.60	0.75	0.45	0.75	52.22%
18	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.50	0.10	7.78%

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

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.

	Objectives (average of students grades for 8 representative p							
Problem	1	2	3	4	5	6	7	8
1	0.74	0.74	0.74	0.74	0.00	0.00	0.00	0.00
2	0.87	0.87	0.00	0.87	0.00	0.00	0.00	0.00
3	0.89	0.89	0.89	0.89	0.00	0.00	0.00	0.00
4	0.93	0.00	0.93	0.93	0.93	0.00	0.93	0.00
5	0.46	0.46	0.46	0.46	0.46	0.00	0.00	0.00
6	0.51	0.00	0.51	0.51	0.00	0.00	0.00	0.00
7	0.41	0.00	0.41	0.41	0.00	0.00	0.00	0.00
8	0.45	0.45	0.00	0.45	0.45	0.00	0.45	0.00
9	0.60	0.60	0.00	0.60	0.00	0.00	0.00	0.00
10	0.33	0.00	0.00	0.33	0.33	0.33	0.33	0.33
11	0.68	0.68	0.68	0.68	0.68	0.68	0.00	0.00
12	0.98	0.00	0.98	0.98	0.98	0.00	0.98	0.00
13	0.34	0.34	0.00	0.34	0.34	0.00	0.00	0.00
14	0.19	0.00	0.19	0.19	0.00	0.00	0.00	0.00
15	0.24	0.24	0.00	0.24	0.00	0.00	0.00	0.00
16	0.48	0.48	0.00	0.48	0.00	0.00	0.48	0.00
17	0.52	0.52	0.52	0.52	0.00	0.00	0.00	0.00
18	0.08	0.00	0.08	0.08	0.08	0.00	0.00	0.00
Subtotals	1.0	0.9	1.0	1.0	1.0	0.7	1.0	0.3

Figure 18. Association of student scores with course objectives.

Objective	1	2	3	4	5	6	7	8	9	10	11
1	3.0	0.0	2.0	0.0	1.0	2.0	0.0	3.0	0.0	2.0	2.0
2	2.7	0.9	1.8	0.0	2.7	0.0	0.0	0.0	0.0	1.8	0.0
3	3.0	0.0	1.0	0.0	3.0	0.0	0.0	1.0	0.0	0.0	0.0
4	3.0	0.0	3.0	0.0	3.0	0.0	0.0	3.0	2.0	2.0	0.0
5	2.0	1.0	1.0	0.0	2.0	0.0	1.0	3.0	0.0	0.0	0.0
6	2.0	0.7	0.7	2.0	2.0	0.0	1.4	0.0	0.0	0.7	0.7
7	1.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.3	0.3	1.0	0.3	1.0	0.3	0.0	1.0	0.7	1.0	1.0

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

In summary, the assessment process results in:

1. Relative weights assigned to outcomes by each course in the ENVE program.
2. Component grade based measures of degree of achievement of course objectives and outcomes.
3. Survey-based measures of degree of achievement of course objectives and outcomes.

4. Comments from students on course deficiencies and possible improvements in course (university administered teaching evaluations).

This information is used by faculty members 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 ENVE 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 faculty member 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 ENVE 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 ENVE 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 ENVE program for the 2004–2005 academic year. The relative outcome distribution is derived from the core curriculum classes for ENVE (all CHE, CEE and ENVE prefix courses plus ME 10 and 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 three technical electives that differentiate the air and water option 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 CEE 158 and ENGR 118 (see notes for outcome 6 and 9 coverage below).

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

Outcomes--->	1	2	3	4	5	6	7	8	9	10	11
Required Engineering Courses											
CEE 10	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
ENVE 120	22.0	6.5	21.1	0.0	22.8	1.6	0.0	5.7	0.0	5.7	14.6
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 135	12.6	11.5	5.8	9.4	7.3	3.1	12.6	9.4	12.6	6.3	9.4
ENVE 142	19.2	4.0	14.1	4.0	19.2	3.0	3.0	13.1	4.0	10.1	6.1
ENVE 146	14.4	0.0	14.4	0.0	15.6	5.6	5.6	11.1	5.6	11.1	16.7
ENVE 160C	8.5	10.2	8.5	15.3	11.0	5.9	9.3	4.2	5.1	6.8	15.3
ENVE 171	17.1	1.4	10.0	0.0	20.0	8.6	8.6	5.7	4.3	8.6	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
ME 10	39.0	0.0	3.9	0.0	23.4	2.6	0.0	0.0	0.0	0.0	31.2
ENGR 118	14.1	11.3	4.2	8.5	16.9	1.4	14.1	4.2	0.0	2.8	22.5
Air Option											
CHE 116 (TE#1)	27.8	7.2	13.4	1.0	26.8	2.1	3.1	2.1	2.1	1.0	13.4
ENVE 134 (TE#2)	25.3	2.5	19.0	0.0	30.4	1.3	0.0	8.9	0.0	8.9	3.8
CEE125 (TE#3)	9.6	32.7	0.0	9.6	0.0	0.0	17.3	5.8	3.8	21.2	0.0
CEE 132 (TE#3)	20.0	2.4	3.5	7.1	11.8	4.7	14.1	12.9	5.9	10.6	7.1
CHE 102 (TE#3)	18.3	10.0	6.7	7.5	15.0	5.0	10.0	7.5	7.5	7.5	5.0
TE water											
CHE 124 (TE#1)	34.0	11.3	17.0	1.9	28.3	0.0	3.8	0.0	3.8	0.0	0.0
CHE 116 (TE#2)	27.8	7.2	13.4	1.0	26.8	2.1	3.1	2.1	2.1	1.0	13.4
CEE 125 (TE#2)	9.6	32.7	0.0	9.6	0.0	0.0	17.3	5.8	3.8	21.2	0.0
CEE 132 (TE#3)	20.0	2.4	3.5	7.1	11.8	4.7	14.1	12.9	5.9	10.6	7.1

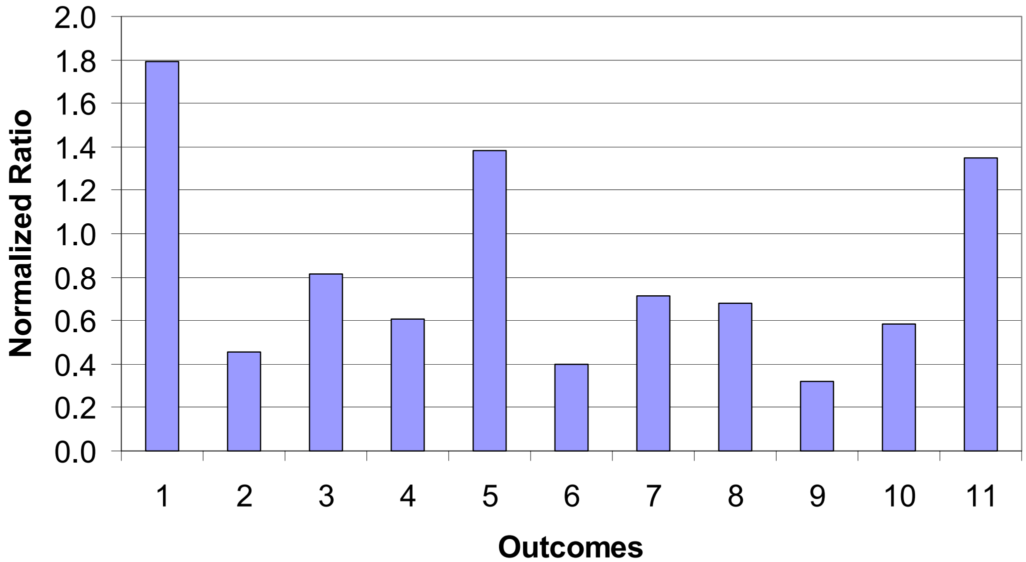

Figure 20. Relative distribution of outcomes 1-11 for the overall ENVE program for the 2004 –2005 academic year.

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 outcome 9. It was also noted that outcome 6, while at the threshold, may need more attention. 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. 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, CEE 158 and the capstone senior design courses (175AB).

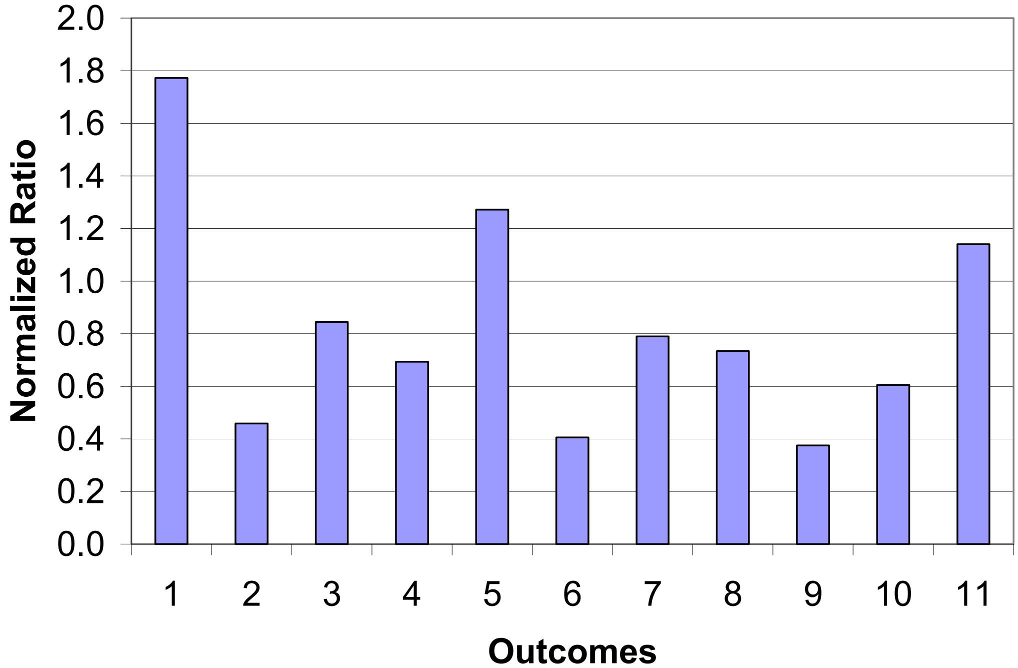

Figure 21. Relative distribution of outcomes 1-11 for the overall ENVE program for the 2005 –2006 academic year.

For completeness, Figures 22 and 23 show the relative outcome ratios for the technical electives offered for air quality engineering option and water quality engineering option, respectively. They are in general agreement with the overall weightings seen for the ENVE core curriculum.

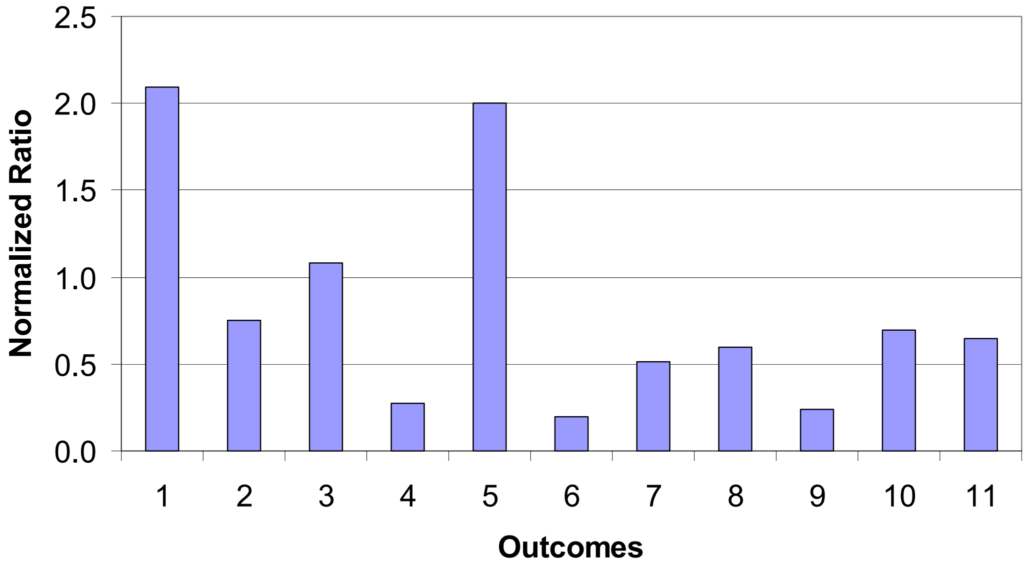

Figure 22. Relative outcome distribution for outcomes 1-11 for air quality engineering technical electives (3 courses).

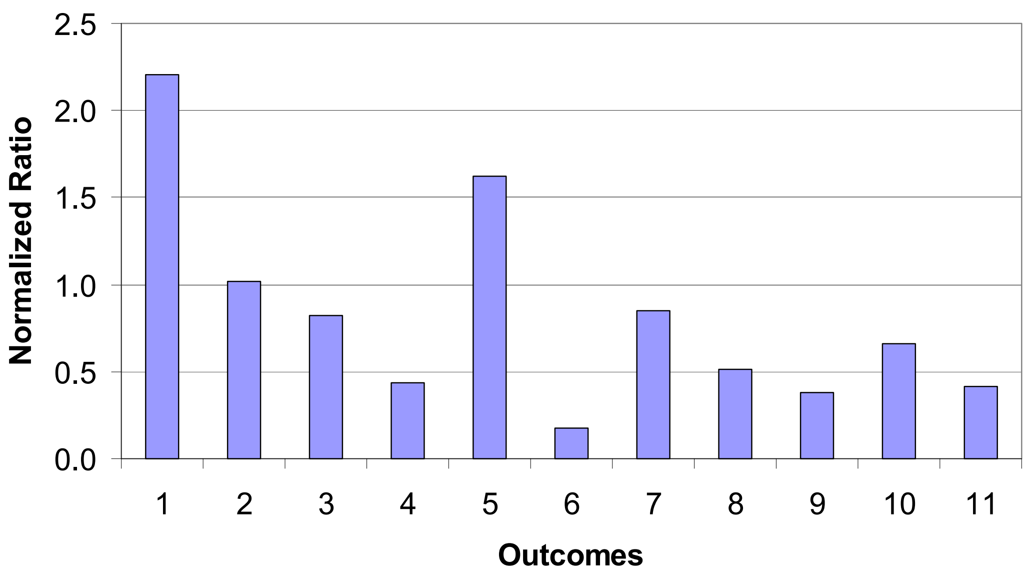

Figure 23. Relative outcome distribution for outcomes 1-11 for water quality engineering technical electives (3 courses).

Outcome 1: An ability to apply knowledge of mathematics, science and engineering
The majority of the ENVE courses are designed to address this outcome, as reflected in Figure 20 and Table 5. In 2004-2005, the relative outcome weighting was 1.79 for this outcome. ENVE 171, Introduction to Environmental Engineering, is the first course to emphasize the application of science and mathematics to engineering problems and is currently designed to be taught at the beginning of the sophomore year. This is followed by CHE 100 (Introduction to Engineering Thermodynamics) and CHE 130 (Advanced Engineering Thermodynamics), both thermodynamic courses, which 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 ENVE curriculum courses with a relative distribution score of 0.45. Several key courses present in the curriculum are significantly weighted toward this goal including the hallmark required laboratory courses series ENVE 160 ABC (Environmental Engineering Laboratories). Additionally, CEE 125 (Analytical Methods for Chemical and Environmental Engineers) is a technical elective for both the air and water program options. 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. The senior design project (ENVE 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 0.82 in 2004-05 in the ENVE 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 ENVE courses with significant weightings for outcome 3 include CHE 114 (Applied Fluid Mechanics), ENVE 120 (Unit Operation and Processes in Environmental Engineering), ENVE 134 (Technology of Air Pollution Control), ENVE 142 (Water Quality Engineering) and ENVE 146 (Water Quality Systems Design). 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, and in ENVE 146, students were asked to respond to a request for proposal (RFP) soliciting engineering services for the design and construction of a sanitary sewer system or a storm drain system for an urban development with specific constraints. The capstone design courses, ENVE

175A and 175B, as well as CEE 158 (Professional Development for Engineers) pay special attention to ethical and health and safety concerns in design. All courses, by virtue of the degree, stress environmental concerns. ENVE 175 A and B also require consideration of economics, feasibility, and sustainability issues. Green Engineering (CEE 132), a technical elective available for both air and water 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 project, requiring team members from both ENVE and CHE and from diverse backgrounds to function together to achieve project goals. For example, CHE 114 (Applied Fluid Mechanics) is a required course for both majors with the design teams evenly integrated between majors. Furthermore, within the ENVE major specific courses, students pursuing degrees with the water and air option are grouped together for team solutions. Key courses involving teamwork (both intradisciplinary and multidisciplinary) as a large fraction of the course are the laboratory courses (ENVE 160ABC, Environmental Engineering Laboratory, and CEE 125, Analytical Methods for Chemical and Environmental Engineers) and the senior design course (ENVE 175AB). Within these courses, students work in teams to prepare technical memoranda, technical reports, and oral presentations. A relative distribution score of 0.60 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 1.38 (second only to outcome 1), is emphasized in the majority of the courses in the ENVE curriculum. This outcome is stressed throughout the sophomore, junior, and senior level courses. This outcome is first addressed in the sophomore year in Introduction to Environmental Engineering (ENVE 171) and the two Chemical Thermodynamic Courses (CHE 100, CHE 130) 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 environmental engineering, CEE 10 (Introduction to Chemical and Environmental Engineering), 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, e.g., in sophomore courses ENVE 171 (Introduction to ENVE), and strongly reinforced in senior courses CEE 158 and the design courses ENVE 175A and 175B, which have several lectures devoted to 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 ENVE courses although specific lectures on the topic are not necessarily provided. The ENVE curriculum had a 0.4 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).

Outcome 7: An ability to communicate effectively
Students are required to write design reports and make oral presentations in several courses. The capstone design course, ENVE 175AB, emphasizes this outcome as do the laboratory courses ENVE 160ABC and CEE 125. Many other classes 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 0.71. 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 and ENVE 160AB deal explicitly with this outcome. Additionally, required courses ENVE 133 (Fundamentals of Air Pollution Engineering) and ENVE 142 (Water Quality Engineering) ENVE 146 (Water Quality Systems Design) also 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. For example, discussion of local versus regional air quality issues, such as fine particulate matter, are discussed in light of control strategies. Riverside air quality and methods to control poor air quality are discussed in light of goods movement related emissions (impact of the Port of Los Angeles, such as heavy-duty diesel on-road emissions, locomotives, and marine engines), industry, personal transport, and dairy emissions. Other lectures include haze issues in national parks, sulfur-related emissions in the Northeast U.S., and global climate change. The relative distribution score of this outcome in the 2004-2005 curriculum is 0.68.

Outcome 9: Recognition of the need for and an ability to engage in lifelong learning
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 advisors 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 0.32 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 (see also Figure 21).

Outcome 10: Knowledge of contemporary issues
Several courses assign problems and design projects that require students to be aware of contemporary issues. For example, students in ENVE 133 have several group discussions on the causes and impacts of global climate change, emissions related to goods movement, current state of knowledge of health effects from key atmospheric pollutants, etc. The term project in ENVE 146 deals with the environmental control requirements of a new urban development and deals with the issue of storm-water runoff. This year, in ENVE 120, students had to identify a mix of chemical pollutants (such as from a damaged petroleum refining plant) likely present in the

floodwaters from Hurricane Katrina and identify possible clean-up strategies. Professors for each class incorporate their own research programs into course material to ensure discussion and knowledge of contemporary issues. CEE 10 discusses contemporary issues in Environmental Engineering during the freshman year to engage students in their major and increase student retention rates. CEE 125 is designed for students to use experimental design and instrumentation and apply them to current issues such as water quality. Further, 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 0.59.

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 1.35, 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 (ENVE 160ABC) and the senior design project (ENVE 175AB series). Other examples of modern engineering tools include using computer data acquisition in the ENVE 160ABC series, the introduction to the WaterCAD, StormCAD, SewerCAD, PondPack, FlowMaster, CulvertMaster softwares, and SWIMM model by EPA, and H2Optimize by Fairbanks Morse in ENVE 146 (Water Quality Systems Design).

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).

Figures 24 and 25 present a summary of student performance for each outcome in all required ENVE courses (except for three technical electives, to allow for simpler identification of student outcomes). 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 ENVE 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 ENVE students.

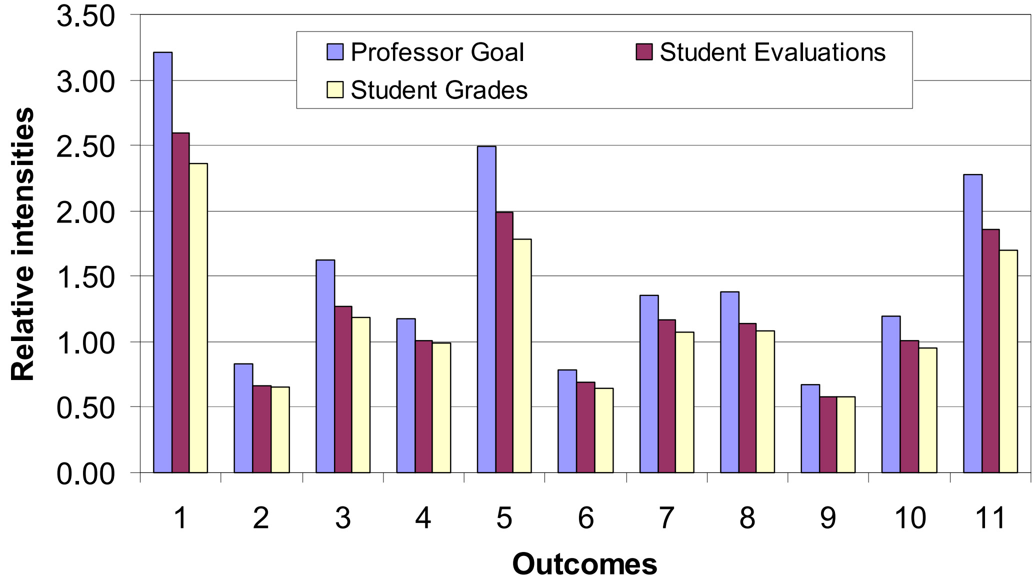

Figure 24. 2004-05 outcome assessment for ENVE program, absolute scale.

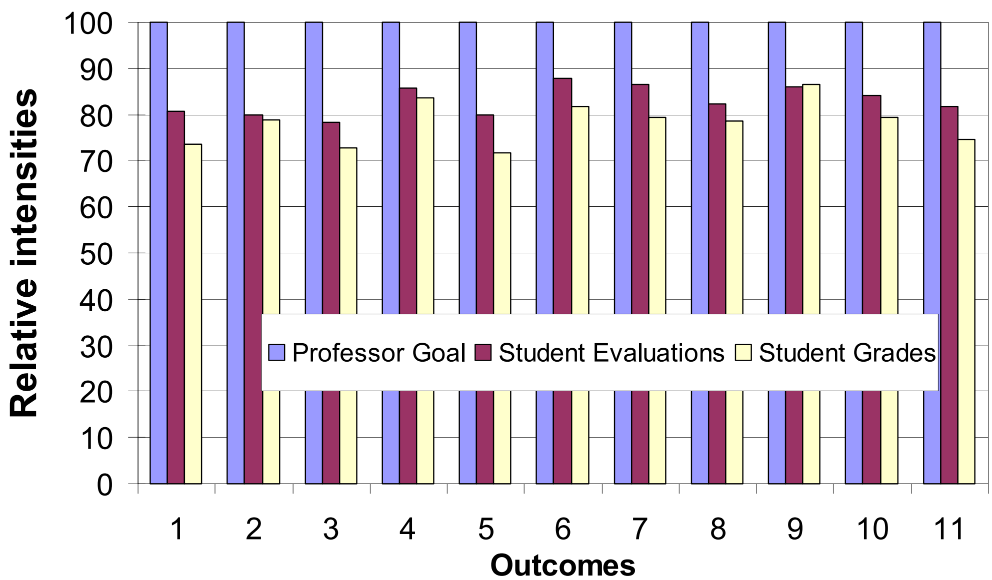

Figure 25. 2004-05 outcome assessment for ENVE as a percent of ideal scores.

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 78% for outcome 3 (An ability to design a system, component, or process to meet desired needs). Nearly all outcomes, averaged throughout the program, were in the 80-85% range. 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 83%, their grades reflected a score of 78%. The faculty was encouraged that the discrepancy between student evaluation and student grades was relatively small.
- It was determined that all outcomes met the minimum student grade threshold of 70%. It was noted that student grades for outcome 3 (73%) and outcome 5 (72%) were closest to our threshold score and warranted a close look over the upcoming year. Since all scores met 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 3 and 5 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 1 (73%) and outcome 11 (75%), while above our preset minimums, 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 grades for outcomes 4 (84%) and outcome 9 (87%) were exceptionally high, indicating especially strong performance/coverage on teamwork and the recognition for the need of lifelong learning.

Scores on technical elective (TE) courses generally reflected those of the ENVE core classes. Figures 26 through 29 summarize performance on ENVE technical electives for air quality control option and water quality control option. 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 year's 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.

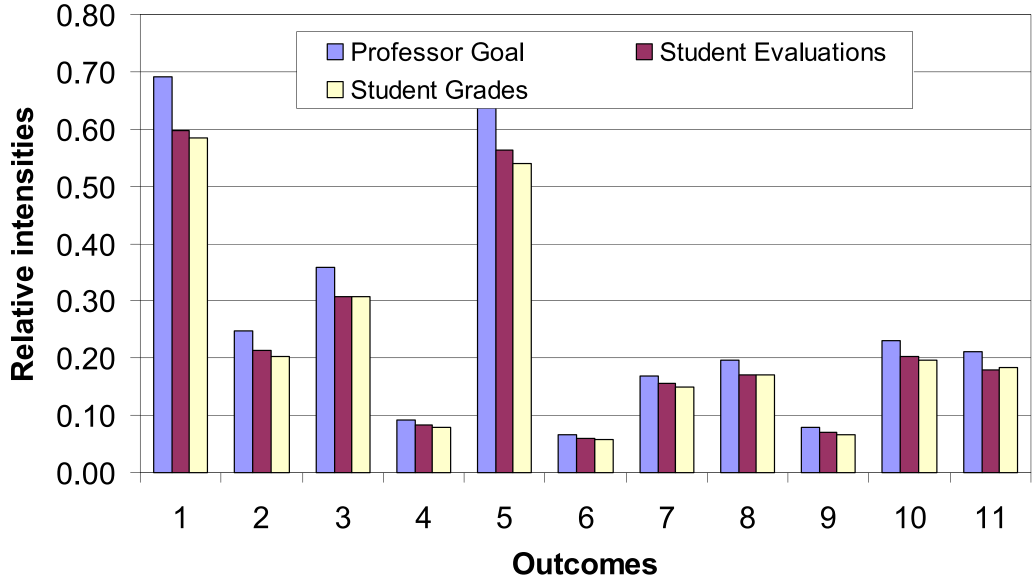

Figure 26. 2004-05 outcome assessment for technical electives (3) for air quality control option, absolute scale.

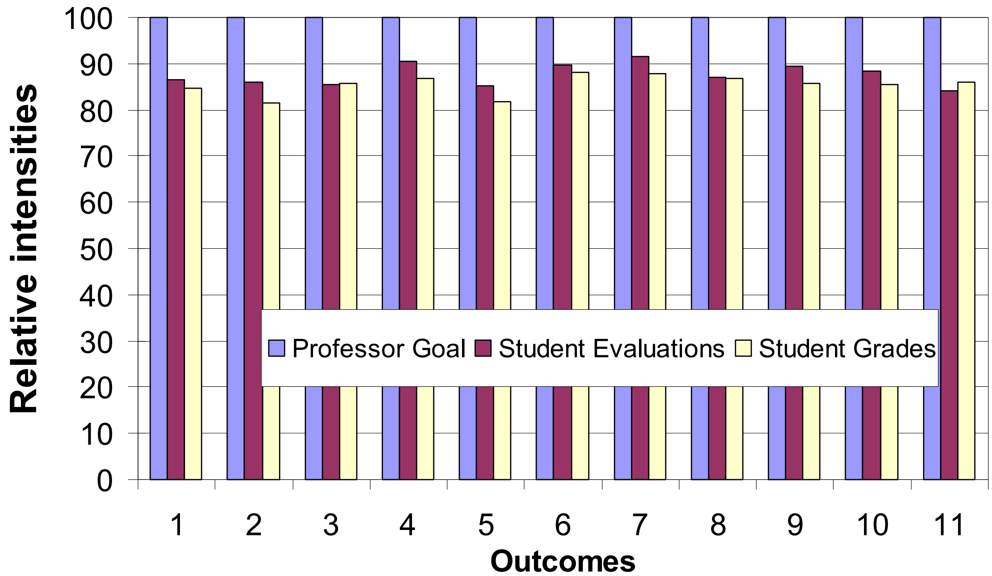

Figure 27. 2004-05 outcome assessment for technical electives (3) for air quality control engineering option, as a percent of ideal scores

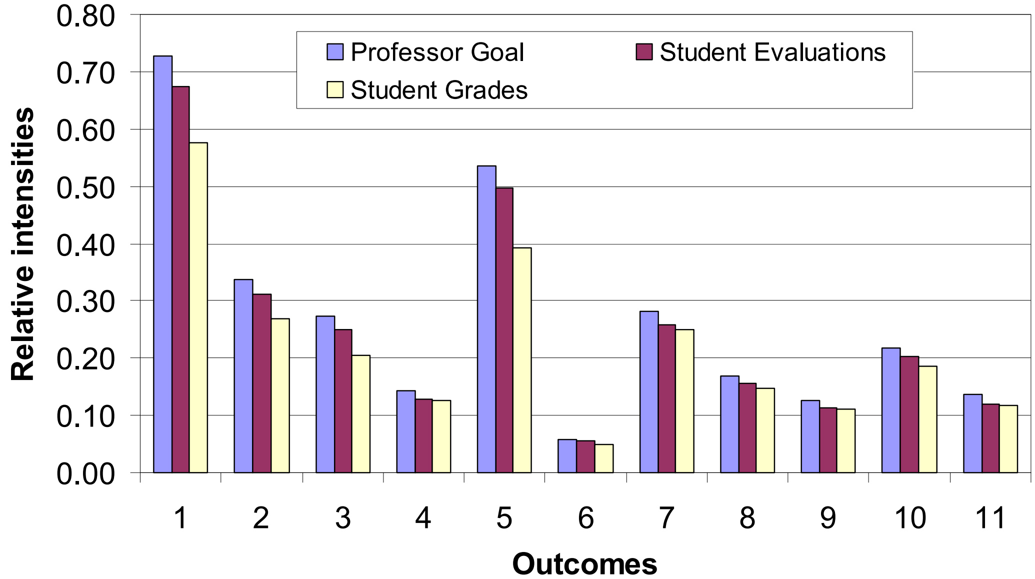

Figure 28. 2004-05 outcome assessment for technical electives (3) for water quality control option, absolute scale

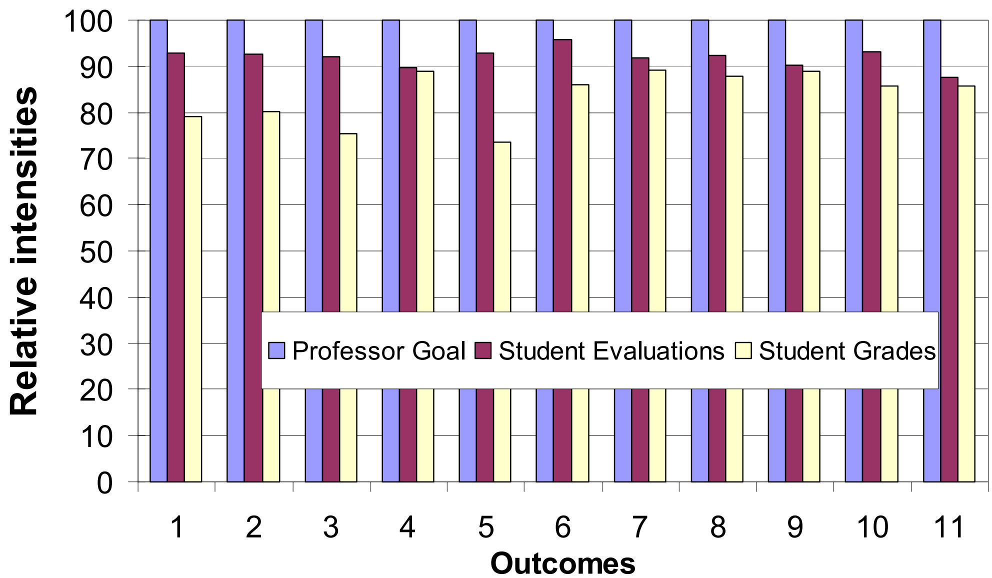

Figure 29. 2004-05 outcome assessment for technical electives (3) for water quality control engineering option, as a percent of ideal scores

The alumni survey was also used to evaluate how well our alumni believe that the ENVE 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.

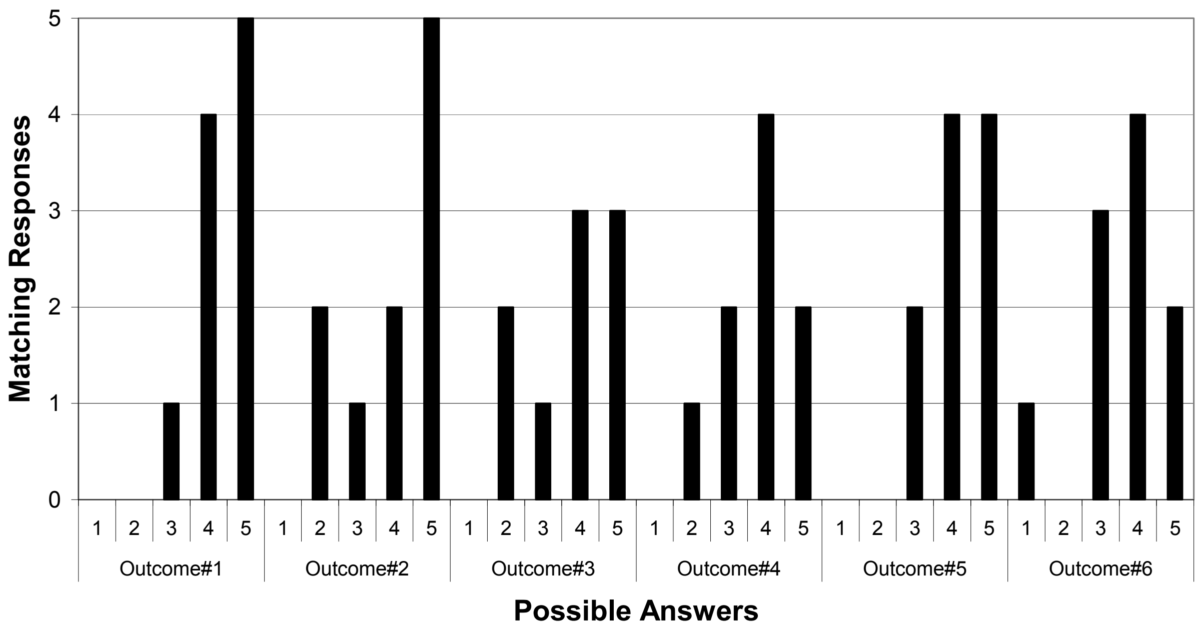

Figure 30. Alumni evaluation of achievement for outcomes 1-6.

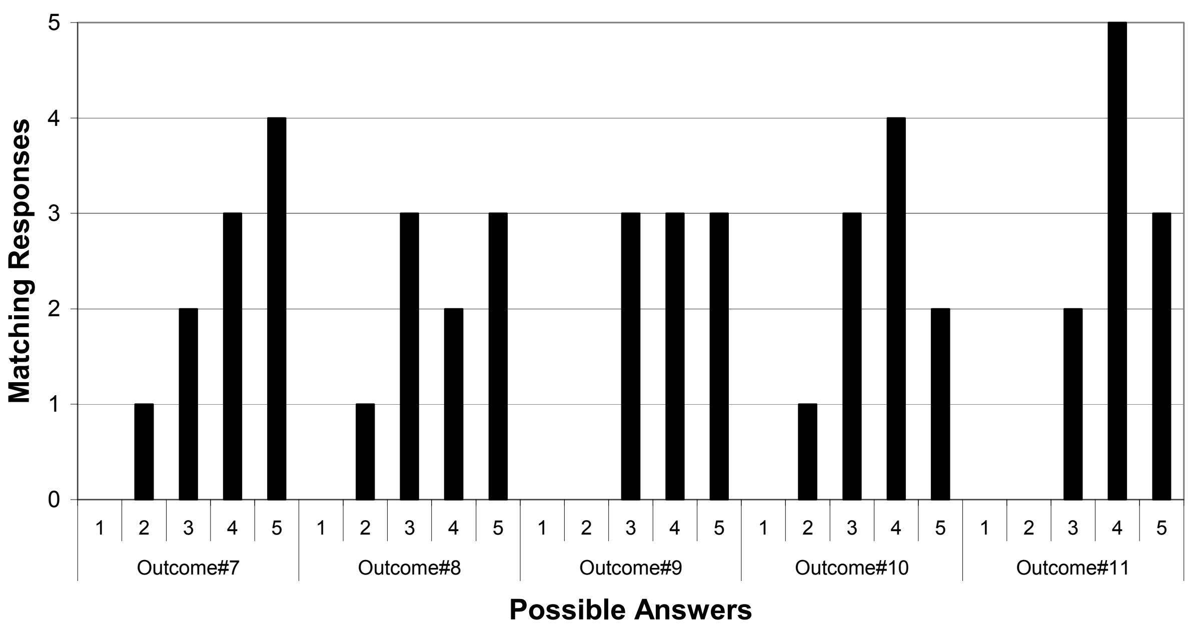

Figure 31. Alumni evaluation of achievement for outcomes 7-11.

Table 6. Average outcome score, alumni survey.

Outcome	Average Score
Outcome#1	4.4
Outcome#2	4.0
Outcome#3	3.8
Outcome#4	3.8
Outcome#5	4.2
Outcome#6	3.6
Outcome#7	4.0
Outcome#8	3.8
Outcome#9	4.0
Outcome#10	3.7
Outcome#11	4.1

Average scores for the outcomes ranged from 3.6 (outcome 6) to 4.4 (outcome 1). Outcomes 1, 2, 5, 7, 9, and 11 all scored a 4.0 or higher, indicating that the alumni believe that these outcomes were very well addressed and achieved. Outcomes 3, 4, 6, 8 and 10 each scored below a 4.0 (but ≥3.6), indicating areas for possible improvement. Outcomes 6 and 8 have been addressed in the changes in the 2003 catalog year, which added CEE 158 and strengthened ENVE 175A/B. Outcome 4 is addressed through the implementation of team mini-design projects (as opposed to individual) throughout the upper-division curricula. In addition, several courses now create the design teams (as opposed to student choice) to force students to act together on diverse teams with diverse backgrounds (ENVE 175A and 175B, the senior design courses, select teams across student strengths balanced by GPA). Outcomes 3 and 10 were surprising to the faculty, given the faculty's inclusion into most courses their current research programs. A possible explanation for the low score for outcome 3 (Ability to design a system, component, or process to meet desired needs with realistic constraints) is that professional design can be markedly more complex than case studies taught in the classroom as it often integrates a large number of factors. Also, as explained earlier, our teaching is rooted primarily in principles, not techniques. This may have contributed to the lower scores in outcomes 3 and 10. Finally, it is important to note that the major changes in the 2003 catalog year will not become fully apparent until the class of 2006 and 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.

Senior Design Survey

Beginning in 2006, a new survey evaluation targeted at measuring the 10 of the 11 ENVE ABET outcomes (outcome 9, lifelong learning, could not be evaluated) was conducted by all Chemical and Environmental Engineering (CEE) 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 (score 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 anticipated that industry representatives might be invited to the senior design presentations, and also be asked to 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, 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	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. The effectiveness of this survey to date has been limited by the small class size within the ENVE degree program, which has kept the responses from being statistically very significant. A class response rate of 75% (3 of 4), 83% (5 of 6), and 100% (4 of 4) is noted for the 2003, 2004, and 2005 exit surveys, respectively. Figure 32 summarizes the outcome based senior exit survey response for ENVE for 2003-2005.

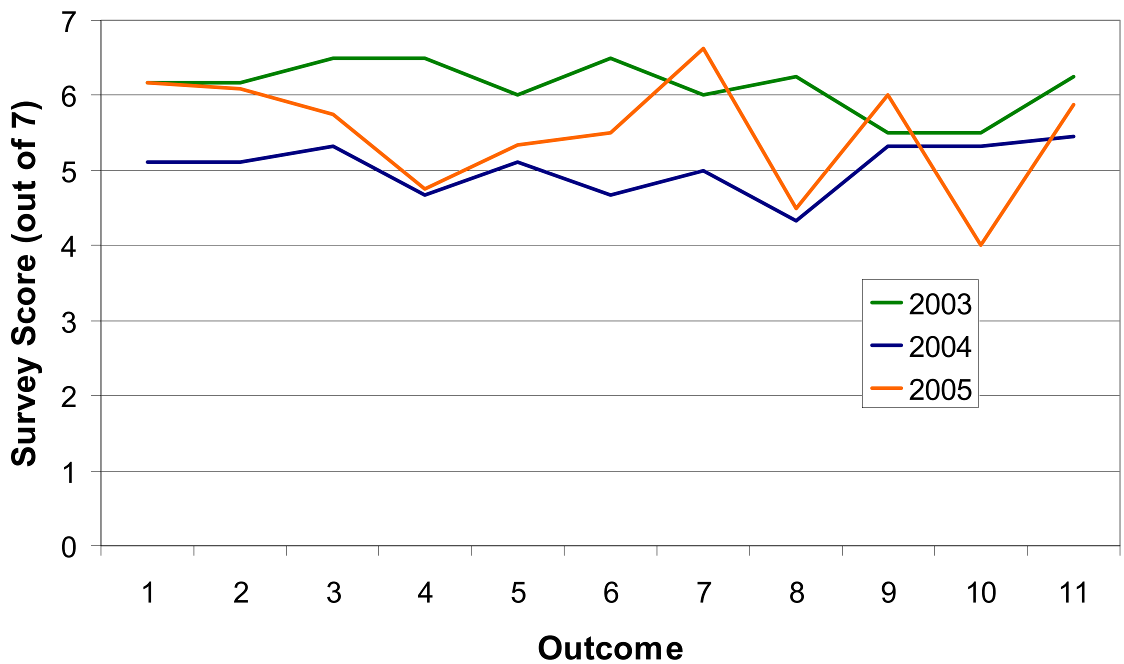

Figure 32. Summary of Senior Exit Surveys for ENVE 2003-2005.

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:

1. an ability to apply knowledge of mathematics, science and engineering
2. an ability to design and conduct experiments, as well as analyze and interpret data
3. 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
4. an ability of function on multidisciplinary teams
5. an ability to identify, formulate, and solve engineering problems
6. an understanding of professional and ethical responsibility
7. an ability to communicate effectively
8. the broad education necessary to the understand the impact of engineering solutions in a global, economic, environmental, and societal context
9. a recognition of the need for and an ability to engage in lifelong learning
10. a knowledge of contemporary issues
11. 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 small, making statistical analysis difficult (total of 12 students replied out of 14 possible for three years).
- With the limitations of sample size noted above leading to large variability and poor statistics, there was a downward trend between 2003 and 2004 with a recovery in 2005.
- No major actions were taken as a result of the surveys alone other than to reiterate the need for continued monitoring. It was noted amongst the faculty that the 2004 class was significantly academically weaker than the 2003 class, which may have contributed to the downward trend. The 2005 class, more reflective of a typical ENVE class (similar to 2003), showed an upward trend.
- 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. An additional class, given larger variability in statistics of small numbers, is needed to confirm this hypothesis.
- The faculty acknowledged reinforced the need for CEE 158 to cover professional issues such as career development, need for lifelong learning, and ethics. This response was in part due to the chemical engineering exit survey data.
- It was noted for ENVE 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 to reflect changes made in 2005 to the junior level courses ENVE 133, ENVE 142, and ENVE 146. It is noted that ENVE 146 for 2006 included a trip to a professional meeting (outcome 8). The committee is generally perplexed by the low rating on interdisciplinary team work and is concerned that the students interpretation of this (Chemical + Environmental teams) may be overlooked since both fall under the same department. If the score remains low for 2006, an informal follow-up meeting with some of the graduating seniors will be deemed necessary to determine why the perception of this outcome is low.
- 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; it is 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 fall, a second questionnaire will examine how well the actual experience matched the expectations.

B.3.6 Changes Made in Response to Assessments

The ENVE program continuously strives to improve the overall student learning process. There have been a number of modifications made to the program in the past several years – 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 education objectives and outcomes. The most significant changes were implemented in the 2002-2003 catalog year to ensure compliance of the ENVE program with the ABET 2000 criteria and as a response to constituent feedback, most significantly from informal discussions with alumni, current students, and the ENVE faculty. Another key objective for these changes was improvement of undergraduate retention. These changes are briefly discussed below.

Removed from the ENVE 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), Mechanical Engineering 110A (Mechanics of Materials), and Chemistry 112C (Organic Chemistry). It was determined that the key desired concepts covered in EE 1A/1AL were already covered in Physics 40 C/40 CL. ME 110A was originally included in the curriculum to aid students taking the EIT/FE exam. However, it was determined that the key concepts within this course (as well as any missed from EE 1A) could be covered within a newly introduced professional engineering course (CEE 158, Professional Development for Engineers). A review of the material covered in CHEM 112 (organic chemistry) series revealed that the key concepts needed for atmospheric and water chemistry were covered sufficiently well in the first two courses CHEM 112AB. Therefore, CHEM 112C was removed from the curriculum.

The cumulative removal of these three courses provided room for the introduction of three new courses: ENSC 100/100L (Introduction to Soil Science) in direct response to an ABET review comment from the previous accreditation; CEE 10 (Introduction to Chemical and Environmental Engineering), a new course designed to introduce the field of ENVE 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, EIT/FE concepts not covered by the program, etc.

The removal of these courses also allowed for a restructuring of the ENVE curriculum to provide students with an earlier engineering experience. This served two critical roles:

1) Improved student retention. It was determined that most ENVE dropouts occurred during the first two years of the major program, before the students had a chance to take a course from the ENVE faculty. The introduction of the freshman course CEE 10 and the second-year courses (ENVE 100, Engineering Thermodynamics, ENVE 130, Advanced Engineering Thermodynamics, and ENVE 171, Introduction to Environmental Engineering) provided the students with an earlier look at the components of their major, professional development, and background on what environmental engineering career paths were available. In addition, 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.
2) Improved professional experience. Informal discussion among recent graduates 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 EIT/FE concepts. The course, combined with the senior design project, also provided an ideal platform to discuss engineering ethics.

Additionally, ENVE 144 (Solid Waste Management) and CHE 116 (Heat Transfer) were removed from the required course curriculum and offered within the choice of technical electives (TEs). The technical electives (12 units) discriminate the water and air options for the ENVE degree program. The TEs were restructured to guide the students to select a course from each of three key TE areas. The original TE structure was to allow students to select any 12 units from a list of TE choices. The change was made to ensure that several key courses for each option were selected, especially after the list of TEs were expanded to include CEE 125 (Analytical Methods for Chemical and Environmental Engineers) and CEE 132 (Green Engineering).

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 changes at the course level have been implemented. Use of the end-of-quarter class assessments based on student feedback, student grades, and instructor evaluation provide a documented method for implementation of course level improvements. One such example is provided below, for the winter 2005 offering of ENVE 142, Water Quality Engineering, a required course. The matrix outcome analysis (Figure 33) is provided, along with assessment documentation, and finally we provide an evaluation of the effect that resulting changes had on achievement of the outcomes.

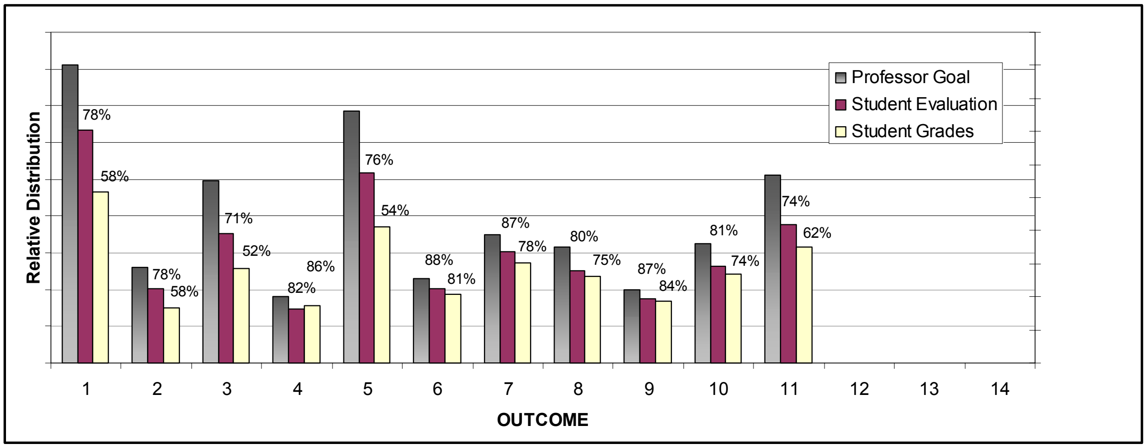

Figure 33. Matrix output for Winter 2005 ENVE 142 course.

Assessment of ENVE 142 (Winter 2005)
Instructor: S. Walker

Observations

Objectives:

1. *To achieve student survey and grades consistently at or greater than 80% for all eight course objectives.*
2. *To achieve student grades above 90% for course objectives most critical for course material (objectives 3, 4 and 7)*

Outcomes:

1. *Student grades did not always correspond to the student survey (perception of performance). Student grades were consistently high except for objectives 6 and 8. For these two objectives student perception was higher than actual grades.*
2. *Student survey results were at 79% (slightly less than goal of >80%) for objective 7.*

Comments and suggestions:

Objectives 6 and 8 both resulted in low student grades. These two objectives were specifically task based, with the objectives focusing on problem solving, technical judgment and communication skills. The students in this particular course had challenges with complex problem solving and critical thinking. The best work they did (and grades achieved) was on the group work/project and quizzes when their skills could be combined towards the determination of a solution.

When this course is taught in the future, significantly more emphasis will be placed on problem solving approaches and critical thinking skills at the start of the course. The first discussion period of the course will be spent to explain the expected level of detail and method of approach for problem solving. This will be further expanded upon and developed throughout the course.

Student perception, as shown by the student survey indicates the students felt they had achieved 79% knowledge of transport mechanisms covered. However their performance on homework and exams (as indicated by the student grades) showed they had mastered the material covered (with a 98% on the grades).

When looking at the relative distribution of scores for the Outcomes, numbers 2, 4, 7, and 9 were below a certain threshold (relative value of 4) for all three items – the professor goal, student evaluation and student grades. This indicates that these items were not a major focus of the course material and approach. Outcome 2 involves designing and conducting experiments which were not a significant part of the course, as this outcome was addressed indirectly. Outcome 4 involved multidisciplinary teams, which was a teaching tool only utilized in the context of the group project. In the future, the course would likely benefit with more group work on homework assignments as the students performed well in groups. Outcomes 6 and 7, on ethical responsibility and communication, were not emphasized in more than just course discussion. The particular focus of this class is not on developing this particular skill set. Therefore, this area doesn't necessary need further development. Outcome 9, on lifelong learning, was not a major *focus of the class. However, an effort was made to expose students to the issues pertaining to the class that made mention in the local paper and other forms of mass media. Therefore in the future Outcome 9 will likely be emphasized to a greater extent, and likely not rise above this threshold further.*

The following year's assessment and outcome matrix for the same course are shown in Figure 34.

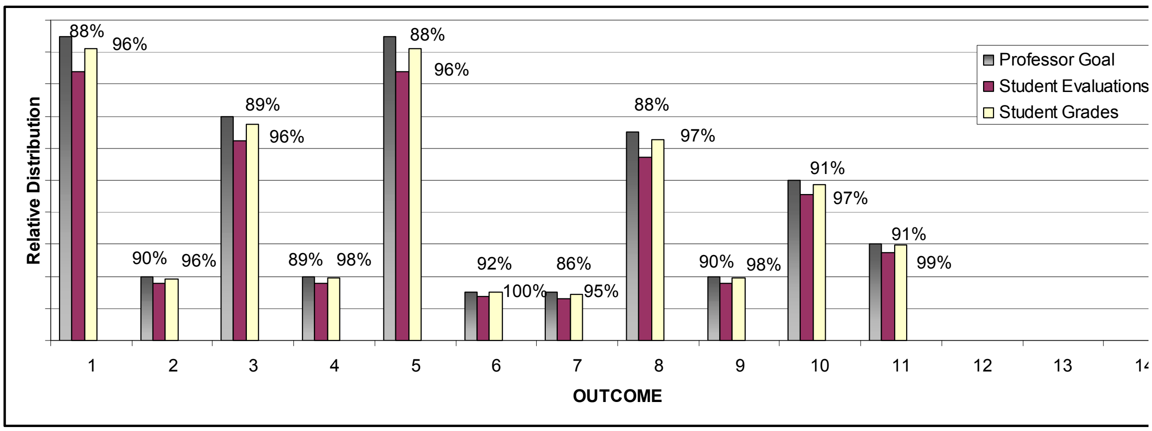

Figure 34. Matrix output for Winter 2006 ENVE 142 course.

Assessment of ENVE 142 (Winter 2006)
Instructor: S. Walker

Observations

Objectives:

1. *To achieve student survey and grades consistently at or greater than 80% for all eight course objectives.*
2. *To achieve student grades above 90% for course objectives most critical for course material (objectives 3, 4 and 7)*
3. *To address issues raised during instruction of course Winter 2005*

Outcomes:

1. *Student grades were quite high – all over 90%!! Student evaluations indicated the perception was that they were performing to a lower level than they actually were (evaluations were 6-9 percentage points lower than grades).*
2. *The additional emphasis this term on problem solving approaches resulted in objectives 6 and 8 having outstanding student performance (evaluations) and grades this year.*

Comments and suggestions:

When I taught this course previously (Winter of 2005) it was apparent that the students needed additional help with problem solving skills. Therefore, this term the course began with an informal introduction to problem solving approaches. Additionally, during class when examples were presented to the students, additional emphasis was put on the method of solutions and stepwise approach. The importance of problem solving skills is captured in objective 6, and although it may look less important relative to the other 7 objectives based upon the relative distribution plot, it was not. The matrix shows for objective 6 the students' performance met my goals (100%) and the student perception was at 92%! I feel modified approach was quite successful based upon the indications of student performance and the matrix.

Outcomes numbers 2, 4, 6, 7, and 9 were below a certain threshold (relative value on matrix figure) for all three items – the professor goal, student evaluation and student grades. This indicates that these items were not a major focus of the course material and approach. Outcome 2 involves designing and conducting experiments which were not a significant part of the course, as this outcome was addressed indirectly. Outcome 4 involved multidisciplinary teams, which was a teaching tool only utilized in the context of the group project. Outcomes 6 and 7, on ethical responsibility and communication, were not emphasized in more than just course discussion. The particular focus of this class is not on developing this particular skill set. Therefore, this area doesn't necessary need further development. Outcome 9, on lifelong learning, was not a major focus of the class. However, an effort was made to expose students to the issues pertaining to the class that made mention in the local paper and other forms of mass media.

Even though outcomes of broad education, ethics and lifelong learning were not primary emphases of this course, these were regularly touched on through informal class discussions. In particular, I brought in articles relevant to the course (issues of water pollution and treatment, *relevant locally and globally) for general discussion. The students were engaged in these discussions and left with an improved ability to discuss the general broader implications of the field. This improvement was not measurable based upon this method of assessment, but it was apparent through casual discussions with the students. I intend to continue this "real world" discussion in future quarters by requiring the students to each present one article from the news relevant to the course material during the course of the quarter.*

This example shows how changes are being implemented within each course to be sure that course objectives are met. Some changes may be more substantial and require faculty vote, and various institutional approvals, such as increasing the units from 2 to 3 for the laboratory courses (ENVE 160ABC) and the professional engineering (CEE 158) course, to provide more time to achieve course and program objectives, or to accommodate addition of new objectives.

Discussion amongst the faculty at the 2004 faculty meeting 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 both surveys within the ENVE department made statistical evaluation of changes difficult. While a somewhat downward trend was noted for ENVE, the overall consensus of the faculty was that the sample size was too small to jump to any conclusions. Similarly, the significant improvement of survey performance in 2005 may have been due to low statistics or the change in the 2003 catalog year. 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. It was noted by consensus that the academic quality of the 2004 class was lower than that of the 2003 and 2005 class, which may have also contributed to a possible small decline. 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").

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%)

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, the College of Engineering 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.

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:

1. 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.
2. Minutes of selected meetings and discussions held by faculty and stakeholder groups in relation to the ABET assessment process.
3. Survey forms used to measure attainment of course objectives and outcomes.
4. Laboratory manuals describing experimental procedures.
5. Health and safety manuals used in laboratories.
6. Equipment lists.
7. University evaluations of teaching by faculty members.
8. Videos of final senior design presentations

B.4 Professional Component

The Environmental 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 Environmental Engineering courses 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), Statics (ME 10), and Cell Biology (BIO 5A).

The environmental 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) 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 and CS 10 (Introduction to Computer Science) is 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 in the sophomore year (or junior year for transfer students) introduce students to the fundamentals of environmental engineering. Our curriculum incorporates solid foundations in transport phenomena, thermodynamics and breadth and depth in unit operations, air and water quality engineering. The environmental engineering curriculum emphasizes principles; however, each course trains the students to carry the concepts forward towards creative applications. In the fall of the sophomore or junior year, students learn basic mass and energy balances in ENVE 171 (Introduction to Environmental Engineering). The curriculum then focuses on Thermodynamics (ENGR 100, ENVE/CHE 130), Transport Phenomena (CHE 114 Fluid Dynamics, CHE 120 Mass Transfer, CHE 116 Heat Transfer (optional for the water option)), water quality engineering (ENVE 142 and 146) and Fundamentals of Air Pollution

Engineering (ENVE 133). In the fall quarter of the junior year, students take ENGR 118, which teaches engineering numerical methods: formulation of engineering models and their application through the numerical solution of the governing equations.

Advanced engineering topics taken by seniors include applications of transport phenomena and thermodynamics in Unit Operations and Processes in Environmental Engineering (ENVE 120), Fate and Transport of Environmental Contaminants (ENVE 135), and Solid Waste Management (ENVE 144). 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), Biological Unit Processes (ENVE 121), Technology of Air Pollution Control (ENVE 134), Hazardous Waste Management (ENVE 145), Chemistry of the Clean and Polluted Atmosphere (ENSC 135), Bioremediation (ENSC 155), Green Engineering (CEE 132), and Analytical Methods for Chemical and Environmental Engineers (CEE 125).

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.

As outlined in the next section, engineering design is emphasized in each engineering course. Many of the above courses include a design project. Theoretical concepts are reinforced in laboratories.

<u>Laboratory Experience</u>

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; provide opportunities to work in a team; and 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, 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. ENVE 160B and 160C work on a similar principle. ENVE 160A is followed by ENVE 160B (Environmental Engineering Laboratory), which offered in the fall of the senior year and ENVE 160C, offered in the winter of the senior year. ENVE 160B focuses on kinetics, reactor design, and air pollution (air quality monitoring, chemical reactivity studies, and vehicle emission testing). 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 use their experimental data to evaluate emission standards, environment impact and environmental regulations. ENVE 160C deals with laboratory exercises in water quality engineering and unit processes. Students experiment with coagulation/flocculation, ion exchange, water quality analyses and assessments on real life samples. Students are required to use their experimental data for scale-up purposes or for an application in engineering design.

For a majority of students, the senior design project (ENVE 175A and 175B) offers another opportunity to perform laboratory work. In many cases, the design project requires them 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 ENVE 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 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), Unit Operation and Processes in Environmental Engineering (ENVE 120), Water Quality Systems Design (ENVE 146). 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, 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 approaches. ENVE 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 (ENVE 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 (ENVE 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. 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 is active in 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. 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), 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 Air & Waste Management Association (AWMA), American Institute of Chemical Engineers (AIChE; environmental engineering students are encourage to participate), 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 Environmental 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 Environmental Engineering program, while highlighting UC Riverside's main strength in specific areas, namely air and water quality engineering.
- The equipment and software tools employed in Environmental 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 environmental 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 (Figure 35). 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 portions of ENVE 160B and ENVE 175AB. The air pollution labs for ENVE 160B (about 65% of the course) are conducted at the College of Engineering-Center for Environmental Research and Technology (CE-CERT) facilities located a short distance off-campus. In addition, depending on their senior design project, students in ENVE 175AB may also use faculty research laboratory facilities (mostly located on the 3rd floor of Bourns Hall). The reason for this is that these often require specialized equipment that is used mostly for research. The CEE research laboratories (total >15,000 sqft) are fitted with the latest research equipment.

A summary of some of the equipment and instrumentation available for environmental 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
- 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

Partial view of B134

Partial view of B108

Jar-test apparatus for coagulation, flocculation, sedimentation

Pipe network apparatus

Multi-purpose pump test rig

CSTR apparatus with data acquisition on a laptop

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

A series of new laboratory experiments in air pollution monitoring (for ENVE 160B) is currently being developed at an estimated cost of about $45,000. The new equipment will include particulate matter monitoring instrument, NOx and ozone analyzer, and carbon monoxide analyzer.

Computing facilities are excellent. Currently the department has one computing laboratory fully dedicated to CHE/ENVE students. Bourns B255 (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 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.

Figure 36. The chemical and environmental engineering computer laboratory (B255).

B.6.1 Accommodating Future Growth

Bourns Hall 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.

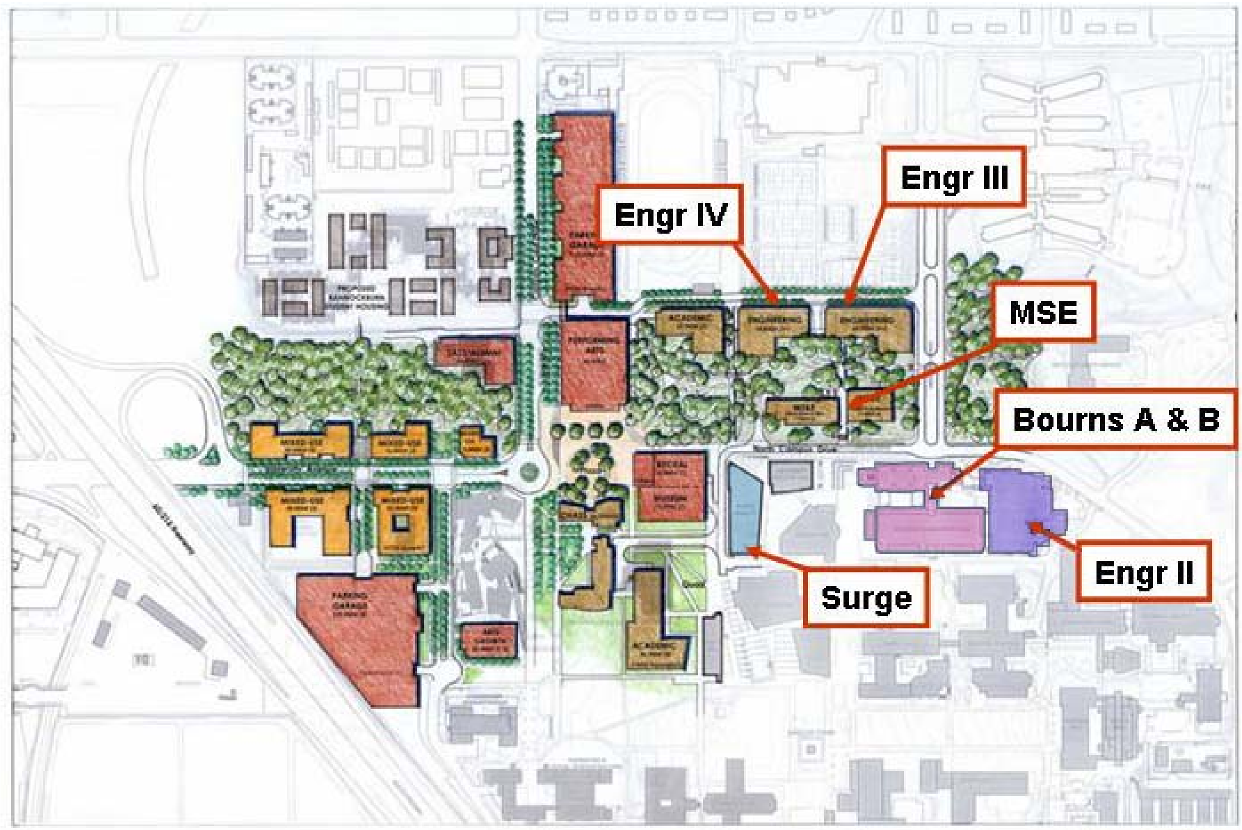

Figure 37. Locations of Bourns Hall (existing) and Engineering II (existing), with the planned Materials Science and Engineering (MSE) Building (2008) and future Engineering III and Engineering IV locations. Surge was the temporary home of the Computer Science and Engineering Department before Engineering 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

B.8.1 Curriculum

Environmental engineering students satisfy ABET Environmental Engineering criteria through a variety of required courses in science and engineering. Often, the ABET Environmental Engineering criteria are reinforced in either laboratory courses (ENVE 160ABC series), or in the technical electives, and are further integrated in the senior design project. Details are provided in Table 9.

Table 9. Fulfillment of ABET Environmental Engineering criteria.

ABET Program Criterion for Environmental Engineers	Course(s) in which the required materials are covered and practiced.
Proficiency in mathematics through differential equations	ENVE students take MATH 9A, 9B, 9C (Calculus), MATH 10A, 10B (Calculus of Several Variables), and MATH 46 (Introduction to Ordinary Differential Equations). All of these courses are the same as those taken by Math majors. Basic mathematic concepts are reinforced through application in a variety of courses including ENVE 171 (Introduction to Environmental Engineering), ENVE 142 (Water Quality Engineering), CHE 114 (Applied Fluid Mechanics), CHE 100 and ENVE 130 (Thermodynamics), ENVE 133 (Air Pollution Control Engineering, ENVE 135 (Fate and Transport), and ENGR 118 (Engineering Modeling and Analysis).
Probability and statistics	Probability and statistics are primarily covered in two courses, ENGR 118 (Engineering Modeling and Analysis) and in ENVE 160A (Chemical and Environmental Engineering Laboratory I). They are used throughout all the laboratory classes for data and error analysis, for curve fitting, etc., and are also used in specific classes for homework or design projects. In laboratory reports, the students present the uncertainty in their results and conclusions using appropriate statistical techniques. Several statistical analyses and curve fitting packages are available for their use (e.g., MatLab, MathCad, Excel). In specified courses, statistical techniques are also applied for engineering analysis.
Calculus-based physics	ENVE students are required to take the PHYS 40ABC series, calculus-based physics courses that are designed for engineering and physical sciences students..
General chemistry	ENVE students are required to take one year of general chemistry CHEM 1ABC (which include laboratories). In addition, ENVE students take two quarters of organic chemistry (CHEM 112A and 112B). All of these courses are the same as those taken by chemistry majors. Additional applied environmental chemistry courses may be taken as technical elective (CHEM 135 (atmosph. chem.), CEE 125 (analytical methods), ENSC 136 (aquatic chem.))

An earth science, e.g., geology, meteorology, soil science, relevant to the program of study	All ENVE students take ENSC/SWCS 100 Introduction to Soil Science. Hydrology (ENSC 163) can be taken as technical elective by students following the water pollution control technology option.
A biological science, e.g., microbiology, aquatic biology, toxicology, relevant to the program of study	All ENVE students take BIOL 5A and 5LA: Introduction to Cell and Molecular Biology, which includes a laboratory. Biological science concepts are applied in several technical electives, including Bioremediation (ENSC 145), or Solid Waste Management (ENVE/ENSC 144). Students following the water pollution control technology option are required to take either CHE 124 (Biochemical Eng. Principles) or ENVE 121 (Biological Unit Processes).
Fluid mechanics relevant to the program of study	ENVE students are required to take CHE 114 Applied Fluid Mechanics. Design and analysis of (hydraulic) environmental engineering systems based on fluid mechanics concepts covered in CHE 114 are covered ENVE 146 (Water Quality Systems Design) which deals with distribution networks, collection systems, pumps and pump stations, etc. Several required courses apply fluid mechanics concepts for specific environmental engineering applications (e.g., air pollutant dispersion in ENVE 135)
Introductory level knowledge of environmental issues associated with air, land, and water systems and associated environmental health impact	These topics are integrated throughout the ENVE curriculum with emphasis in the laboratory courses, ENVE 160B and 160C, and the senior design project, ENVE 175AB. Fate and transport of pollutants in air, water and soil are covered in ENVE 135 and environmental health impacts are presented in ENVE 171; environmental issues associated with air and associated environment health impact are covered in depth in ENVE 133 and 135, water issues and associated environmental health impact are covered in ENVE 120, 142 and ENVE 146; and issues associated with land and associated environment health impact are covered in ENSC/SWCS 100, ENVE 171, and ENVE 135. These are all required courses. Technical electives require students to add a minimum of 2 or 3 courses in either air or water/soil related issues. The senior design project requires that students consider environmental issues and associated environmental health impact in a global context.
An ability to conduct laboratory experiments and to critically analyze and interpret data in more than one major environmental engineering focus areas, e.g., air, water, land, environmental health	Students acquire laboratory skills primarily in the ENVE 160ABC series, although other required courses include laboratories (biology, chemistry, selected electives). ENVE 160A focuses on data acquisition, acquiring good laboratory practice, experimental design and data interpretation, while ENVE 160B and 160C focus on air and water, respectively. The senior design project often requires students to design and conduct their own experiments to determine data unavailable in the literature, verify a hypothesis, or obtain particular engineering data. CEE 125, a laboratory course focused on instrumental analyses is available as a TE for ENVE students. Finally, many of our students also conduct laboratory research as extracurricular activity. See also assessment of ABET Outcome #2 in Section B.3.
An ability to perform engineering design by means of design experiences integrated throughout the professional component of the curriculum	ENVE students gain design experience through a number of required and elective courses that make up the curriculum (see Table IA for presence of design content). Elements of engineering design are included in lectures, laboratories, design projects, homework assignments, and in examination questions. Example of design activities include sizing of equipment to meet a particular need, solving open-ended problems often using iterative approaches, evaluating alternative design solutions. The culmination of the students' design experience is the two-quarter capstone design course, ENVE 175AB, in which students draw upon various aspects of their previous

	engineering science and design knowledge to address a meaningful design problem (see Criterion 4 for more detail on ENVE 175AB). ENVE 146 is another required courses that includes a significant design component. In ENVE 146, students use a variety of modern tools to size equipment or infrastructure to meet a desired objective.
Proficiency in advanced principles and practice relevant to the program objectives	Proficiency in advanced principles and practice relevant to the program objectives is accomplished by providing a balance of breadth and depth in the area relevant to the program objectives (see Section B.2 and B.4 for details on Criterion 2 and Criterion 4). Proficiency in advanced principles and practice relevant to the program objectives is accomplished through both curricular and non-curricular activities. The environmental engineering program has two tracks – air pollution and water pollution control. In each of these tracks, students are directed to take technical electives that provide additional depth to the knowledge, skills, and experience in these specific interest areas. The intention is to better prepare students and enhance their opportunities for positions that focus on either air or water quality engineering issues. Also, all environmental engineering students, upon entry as freshmen, are encouraged to become involved in undergraduate research with a faculty member's research group and/or obtain a career-related internship. Students who engage in these opportunities learn inherently through their directed activities, working with a variety of people who are at various stages of their career and have a wealth of knowledge and experience. Almost all of our environmental engineering students engage in at least one quarter of undergraduate research or internship.
Understanding of concepts of professional practice and the roles and responsibilities of public institutions and private organizations pertaining to environmental engineering.	Students in ENVE are provided with working knowledge of professional practice and the roles and responsibilities of public institutions and private organizations pertaining to environmental engineering primarily in the senior design project (ENVE 175AB). Other courses in which these topics are emphasized include but are not limited to CEE 158, ENVE 146, and ENVE 133. For example, students are told in CEE 158 of the opportunities/benefits associated with professional registration as well as the engineering code of ethics. In ENVE 175 students are required to prepare project schedules, Gantt charts, project files (documentation), progress reports, etc. ENVE 171, ENVE 133 and ENVE 175 include sections about the regulation making process and the need for engineers to engage in the process. In ENVE 146 students are required to obtain state and local design criteria (codes) for water distribution and wastewater sewer systems and use them for the assigned design problems. ENVE 133 spends significant time discussing the role of ENVE in providing cost effective and viable air quality control solutions in the context of public health and welfare.

B.8.2 Faculty

Faculty qualifications are discussed in Section B.5, and biographies are provided in Appendix I.C. All CEE faculty and lecturers are very well qualified to teach the ENVE curriculum, including the courses with significant design content. Teaching assignments are made by the Department Chair in consultation with the faculty, considering individual preferences, teaching history, and teaching performance. A faculty member usually teaches the same courses several years in a row. This provides opportunities and incentives for improving the course, as well as to perfect one's teaching of the subject.

Two of our lecturers (Sheng, Abi-Samra) are licensed Professional Engineers in California, three of our professors (Cocker, Kauffman, Matsumoto) are Engineers in Training (EIT), one lecturer (Perina) is a Registered Geologist and a Certified Hydrogeologist in California with several years of experience in environmental site investigations and remediation. Four of our faculty (Haddon, Miller and Norbeck, Wyman) have each over 20 years of industrial/governmental experience. Many faculty are involved in consulting projects working closely with industry, consulting firms, or regulatory agencies.

The quality of teaching is an important criterion in merit and promotion at the University of California. Teaching evaluations by students, classroom visits (for lecturers), formal and informal feedback from students and colleagues are being used to assess teaching excellence. Several of our faculty have received the Bourns College of Engineering Outstanding Teaching Award.

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. Basic-Level Curriculum

Year; Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics: Engrg Science	Engineering Topics: Engrg Design	Hum. & Soc. Sci.	Other
1; Fall	MATH 9A—First Year Calculus	4					
	CHEM 1A—General Chemistry	4					
	CEE 10—Intro to Chem/Env 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				
	ENVE 171—Intro to Environmental Engineering			4	✓		
	PHYS 40C—General Physics	5					
2; Winter	MATH 10A—Multivariable Calculus	4					
	CHEM 112B—Organic Chemistry		4				
	CS 10—Intro to Computer Science			4			
	CHE 100—Engineering Thermodynamics			4	✓		
2; Spring	MATH 10B— Multivariable Calculus	4					
	ENVE 130—Advanced Engineering Thermodynamics			4	✓		
	ME 10—Statics			4			
	General Elective—H&SS					4	

(continued on next page)

Table I-1. Basic-Level Curriculum (cont.)

Year; Quarter	Course (Department, Number, Title)	Category (Credit Hours)					
		Math & Basic Science	Advanced Chemistry	Engineering Topics		H &SS	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 120—Mass Transfer			4	✓		
	ENVE 133—Air Pollution Engineering			4	✓		
	ENVE 142—Water Quality Engineering			4	✓		
	BIOLOGY 5/5LA—Intro to Cell & Molec. Biology	4					
3; Spring	ENVE 146—Water Quality Systems Design			4	✓		
	ENVE 160A—Chem. & Envi. Engineering Lab			2#	✓		
	Technical Elective 1*			4	✓		
	General Elective—H&SS					4	
4; Fall	ENVE 120—Unit Operations & Processes			4	✓		
	ENVE 160B—Environmental Engineering Lab			2#	✓		
	Technical Elective 2*			0 or 4	0 or ✓		4 or 0
	ENVIRON SCIENCES 100—Intro to Soil Science						4
4; Winter	ENVE 175A—Senior Design Project			4	✓		
	ENVE 160C—Environmental Engineering Lab			2#	✓		
	ENVE 135—Fate & Transport of Envi. Contaminants			4	✓		
	CEE 158—Prof Development for Engineers			3			
4; Spring	ENVE 175B—Senior Design Project			4	✓		
	Technical Elective 3*			0 or 4	0 or ✓		4 or 0
	General Elective—H&SS					4	
	General Elective—H&SS					4	
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		55	8	76, 80 or 84		36	12, 8 or 4
OVERALL TOTAL FOR DEGREE (EQUIVALENT SEMESTER CREDITS)		36.7	5.3	50.7, 53.3 or 56		24	8, 5.3, or 2.7
PERCENT OF TOTAL (187 quarter hours for degree)		29.4%	4.3%	40.6 to 44.9%		19.3%	2.1 to 6.4%
Must satisfy one set	Minimum semester credit hours	32		48			
	Minimum percentage	25		37.5			

* Technical Electives for Air Pollution Control Technology option: (1) CHE 116; (2) ENVE 134; (3) Choose one from CEE 125, CEE 132, CHE 102, ENSC 135/CHEM 135/ENTX 135, ENVE 144/ENSC 144, ENVE 138, ENVE 145

Technical Electives for Water Pollution Control Technology option: (1) CHE 124 or ENVE 121; (2) Choose one from CEE 125, CHE 116, ENSC 136, ENSC 163; (3) Choose one from CEE 132, ENSC 155, ENVE 144/ENSC 144, ENVE 145

#As of Fall 06, unit count for ENVE 160A, ENVE 160B, ENVE 160C has been increased to 3 units each, to better reflect student workload.

Note: The Humanities, Social Sciences, and Biological Science elective options are included in Appendix C&D.

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 (Specify)
ENVE 120	Unit Operations & Processing-Environmental Engineering	1	12	X		X	
ENVE 121#	Biological Unit Processes	*					
ENVE/CHE 130	Advanced Engineering Thermodynamics	1	8	X		X	
ENVE 133	Fundamentals of Air Pollution Engineering	1	6	X		X	
ENVE 134#	Technology of Air Pollution Engineering	1	3	X		X	
ENVE 135	Fate & Transport-Environmental Contaminants	1	8	X		X	
ENVE 138#	Combustion Engineering	*					
ENVE 142	Water Quality Engineering	1	8	X		X	
ENVE 144	Solid Waste Management	1	3	X		X	
ENVE 145#	Hazardous Waste Management						
ENVE 146	Water Quality Systems Design	1	7	X		X	
ENVE/CHE 160A	Chemistry & Environmental Engineering Lab	1	5		X		
ENVE 160B	Environmental Engineering Lab	1	7		X		
ENVE 160C	Environmental Engineering Lab	1	8		X		
ENVE 171	Introduction to Environmental Engineering	1	12	X		X	
ENVE 175A	Senior Design Project	1	8	X	X		Consultation
ENVE 175B	Senior Design Project	1	8	X	X		Consultation
ENVE 190	Special Studies	NA	NA		X		Individual Study Supervised by Faculty
CEE 010	Introduction to Chemical Engineering	2	33	X			
CEE 010	Introduction to Chemical Engineering	3	16		X		
CEE 125#	Analytical Methods for Chemical and Environmental Engineers	1	14	X	X		
CEE 132#	Green Engineering	1	14	X		X	
CEE 158	Professional Development for Engineers	1	27	X			

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

TABLE I-2 (cont.) 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
ENGR 118	Engineering Modeling & Analysis	1	21	X		X	
CHE 100	Engineering Thermodynamics	1	37	X		X	
CHE 102#	Catalytic Reaction Eng.	1	9	X		X	
CHE 114	Applied Fluid Mechanics	1	29	X		X	
CHE 120	Mass Transfer	1	23	X		X	
CHE 124#	Biochemical Eng. Principles	1	8	X		X	

* 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-ENVE/CHE 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-ENVE/CHE 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%		Lecturer/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			State in which Registered	Level of Activity (high, med, low, none)		
					Govt./ Industry Practice	Total Faculty	This Institution		Professional Society (Indicate Society)	Research	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

Fiscal Year	1 2004 (prior to previous year)	2 2005 (previous year)	3 2006 (current year)	4 2007 (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	

IB. Course Syllabi

In Appendix I.B., *Course Syllabi*, provide standard descriptions for courses used to satisfy the mathematics and basic sciences, and engineering topics required by Criterion 4. The format should be consistent for each course, must not exceed two pages per course, and, at a minimum, contain the information listed below:

Department, number, and title of course
Designation as a 'Required' or 'Elective' course
Course (catalog) description
Prerequisite(s)
Textbook(s) and/or other required material
Course objectives
Topics covered
Class/laboratory schedule, i.e., number of sessions each week and duration of each session
Contribution of course to meeting the professional component
Relationship of course to program outcomes
Person(s) who prepared this description and date of preparation

IC. Faculty Curriculum Vitae

In Appendix I.C., provide current summary curriculum vitae for all faculty members with the rank of instructor and above who have primary responsibilities for course work associated with the program. Include part-time and adjunct faculty members. The format should be consistent for each curriculum vita, must not exceed two pages per person, and, at a minimum, contain the information listed below:

Name and Academic Rank
Degrees with fields, institution, and date
Number of years of service on this faculty, including date of original appointment and dates of advancement in rank
Other related experience--teaching, industrial, etc.
Consulting, patents, etc.
State(s) in which registered
Principal publications of last five years
Scientific and professional societies of which a member
Honors and awards
Institutional and professional service in the last five years
Professional development activities in the last five years