College of Engineering
UNIVERSITY OF WISCONSIN–MADISON

ABET Self-Study Report / June 25, 2012

Chemical Engineering Program

at the

University of Wisconsin-Madison

Table of Contents

BACKGROUND INFORMATION

A. Contact Information

Both Department Chair and Assessment Committee Chair are available for pre-visit contact over most of Summer 2012, in consideration of travel plans. The Department Chair is changing on July 1, 2012 as part of the normal 3-year term of the office in the department.

Incoming Department Chair
(July 1, 2012 forward)
Prof. Thomas F. Kuech
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Outgoing Department Chair
(through June 30, 2012)
Prof. Nicholas L. Abbott
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Madison, WI 53706
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Assessment Committee Chair
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B. Program History

The department was founded as the Department of Chemical Engineering in 1905. It was first accredited by AIChE when that organization was formed in 1925. It has been continuously accredited, with the last general review by ABET September 17-19, 2006. In 2005 the department name was expanded to be Department of Chemical and Biological Engineering in recognition of the growing involvement of biology as a foundational science co-equal with chemistry in many of the industrial applications and research activities in the field.

The degree awarded by the program continues to be the Bachelor of Science in Chemical Engineering.

C. Options

The Bachelor of Science in Chemical Engineering is the sole undergraduate degree offered by the Department of Chemical and Biological Engineering. There are no formal options, tracks, or concentrations that require certification by the department. Students who chose to obtain a second major, certificate, or other external recognition must satisfy requirements of those programs separately. While some guidance is provided to students on clusters of elective courses to provide a concentration in particular fields of interest, these are informal and advisory, and are not regulated.

D. Organizational Structure

The Department of Chemical and Biological Engineering is structured to administer the program. The Department Chair uses authority delegated from the Executive Committee to establish standing committees overseeing activities in the undergraduate, graduate, and departmental arenas. The undergraduate sector organization for the 2011/2012 academic year is (chairs indicated in **bold**):

Undergraduate Associate Chair: Murphy
Curriculum: **Klingenberg**, Kuech, Murphy, Nealey, Rawlings, Root
Assessment: **Root**, Murphy
TA Assignments: Palecek
Scholarships: Murphy
Summer Lab: Root
International Programs: Root
AIChE Advisor: Reed
APCRC representative: Klingenberg

Department-wide committees relevant to the undergraduate program include:

Space and Infrastructure: **Nealey**, Kuech, Lynn, Swaney
Safety: **Lynn**, Klingenberg, Swaney
APC representative: Rawlings

The Undergraduate Associate Chair works with the Undergraduate Records Examiner to ensure the needs of the students in the program are met. In 2009 a full-time Faculty Associate joined the department to help faculty develop educational materials and facilitate student participation in diverse opportunities. Within this role, he has expanded his undergraduate research oversight responsibilities to assist part-time in undergraduate advising, providing expertise on satisfaction of academic requirement and expanding involvement in elective enrichment opportunities. These two staff members focus on supporting undergraduate advising and support the primary faculty advisors as a team.

The Department of Chemical and Biological Engineering resides in the College of Engineering, which is led by the Dean of Engineering. The organizational structure within the College of Engineering is displayed below in Figure B-1, which shows the additional support entities that assist with students, facilities, and research activities. The operating and governance committees are particularly important for functioning of the department. The department chair sits on the Operating Committee, a college-wide organization of department chairs who meet monthly with the College Dean, Associate Dean, and college support staff. The Academic Planning Council provides oversight on large-scale curricular changes (like proposals for new undergraduate majors, new advanced degree programs, and new certificate programs). The chair of the department Curriculum Committee sits on the college-level curriculum committee (Academic Planning, Curriculum, and Regulations Council – APCRC) to monitor and plan changes in college-level or university-level curriculum requirements. Currently, the chair of APCRC is the Chemical and Biological Engineering representative. Many of the other standing committees of the college also have departmental representatives.

The deans of all the schools and colleges report to the provost of the University of Wisconsin – Madison. The full organizational chart of the university is shown here in Figure B.2, which shows the upper administration of the university and the reporting chain up to the Board of Regents of the University of Wisconsin System. The board and UW-System also have responsibility for the many other 4-year and 2-year campuses of the UW system.

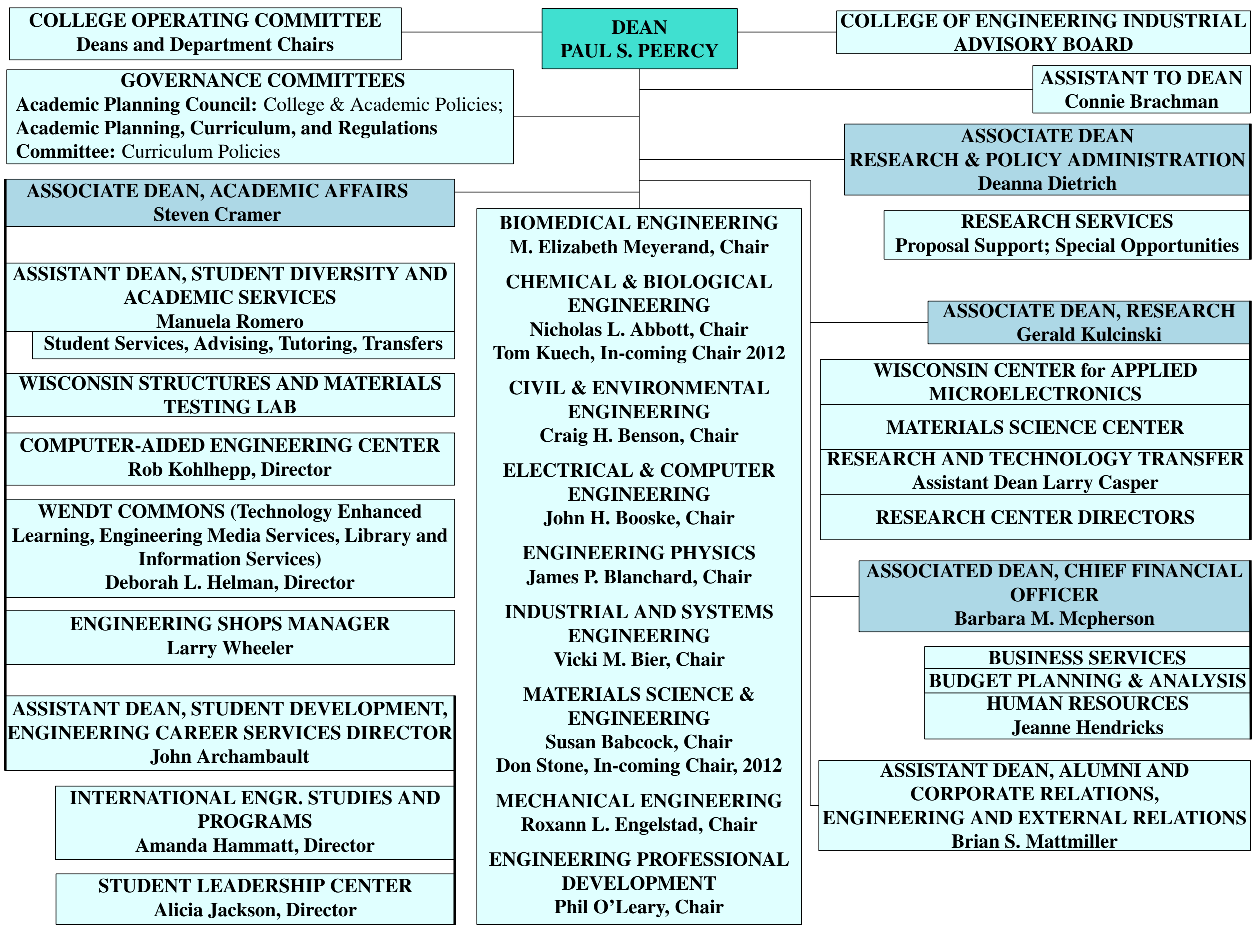

Figure B-1 – Organizational Chart for the College of Engineering

E. Program Delivery Modes

The program is designed for day courses and full-time students. Some students choose to incorporate cooperative education through course CBE 001 as part of their electives. Most courses are offered in traditional lecture/recitation mode or as laboratory sections. Core required courses in the department are presented each semester, both to keep total class size from being too large and to be available for cooperative study students to resume their coursework after a semester off campus without delay. Lecture courses are led by faculty and are typically 40-60 students in size, with the exception of the few courses with substantial outside student enrollment. Recitation sections are scheduled to have approximately 25 students and are led by

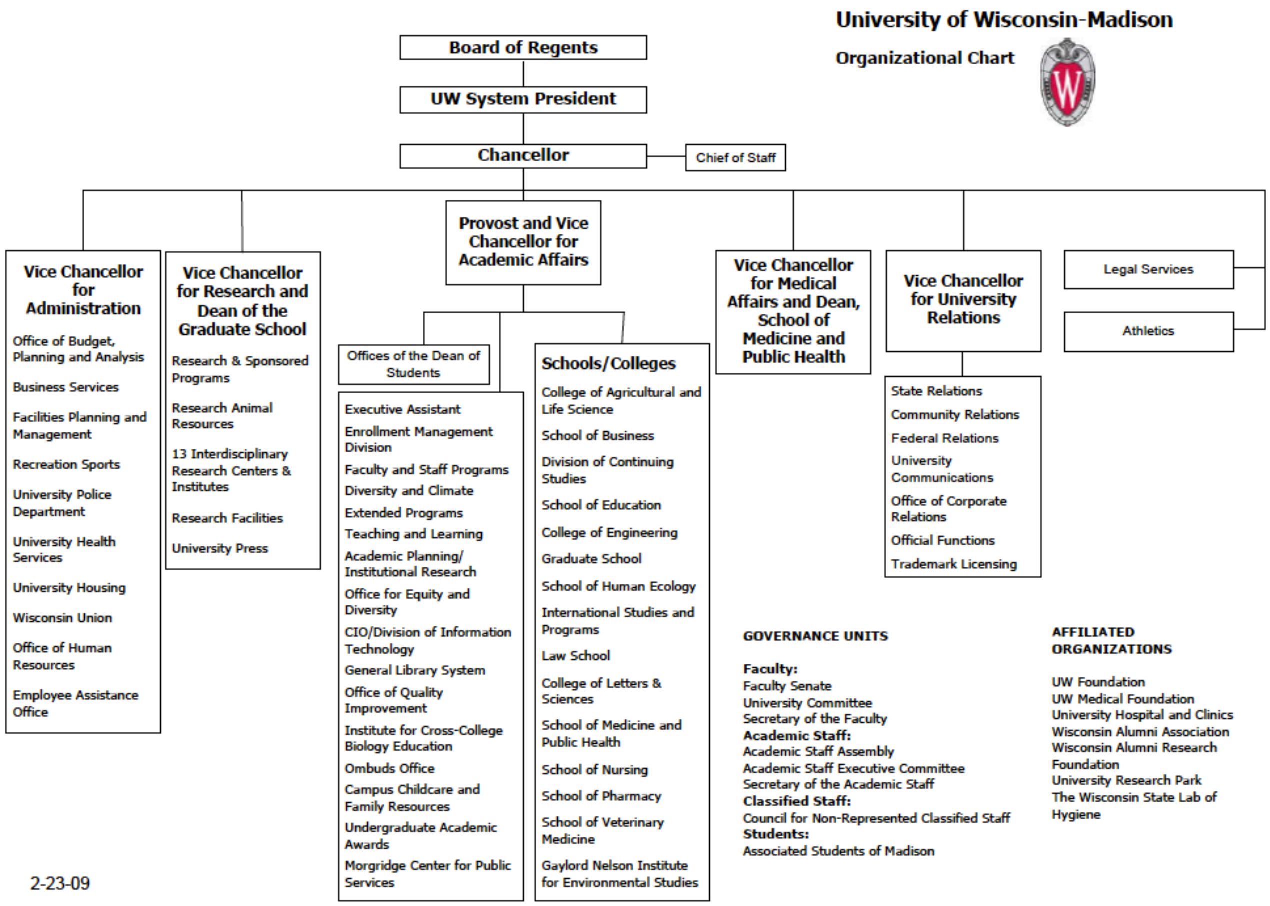

Figure B-2 – Organizational Chart for the Madison campus

Teaching Assistants. Laboratory sections are designed to be 12-16 students during academic year. The Summer Laboratory (CBE 424) has recently had sections with up to 40 students led by 5 instructors for the 5-week, full-time course. More information on course operation is contained in Criterion 5.

Recent incorporation of Technology-Enhanced Learning (TEL) into some courses has allowed reduction in use of large lectures and increased student access to courses. For several years, hybrid instruction using recorded lectures delivered via the web allows students in CBE 255 – Computer Problem Solving to have all contact hours in computer laboratory tutorial sections. In Spring 2012 an experimental section of CBE 320 – Transport Phenomena used recorded live lectures to replace lecture attendance. The faculty member then met in recitation sections with students for problem-solving sessions. Finally, an online version of CBE 250 – Process Analysis with recorded lectures and computer-based quizzes was prepared to improve access to our introductory course. It has been piloted as a summer course in 2011 and will be conducted with a larger group of on-campus and transfer students in summer 2012. When it becomes available off campus for impending transfer students, it will permit students to decrease on-campus minimum semesters from 5 to 4 and thus improve time-to-degree for these transfer students.

Tracking of students taking the off-campus online version will allow the department to measure the impact on residence time to degree and will also be used to improve content and delivery of the online course to ensure that off-campus students receive the same educational experience as the students entering the curriculum on the Madison campus.

F. Program Locations

The program is based on the campus of UW-Madison and nearly all instruction is conducted here. There are two organized exceptions:

- Cooperative education – at plant sites of participating companies
- Overseas summer laboratory – at partner institutions with UW staff participation
  - University of Oviedo, Oviedo, Asturias, Spain
  - Technical University of Vienna, Vienna, Austria

G. Deficiencies, Weaknesses or Concerns from Previous Evaluation(s) and the Actions Taken to Address Them

The ABET Final Statement from the 2006 General Review contained no Deficiencies, Weaknesses, or Concerns. An Observation highlighted particular assessment tools in use, and also remarked on the department tradition of writing textbooks. The prior ABET review had stated a Concern that the Assessment program was quite elaborate and questioned whether the 17 assessment tools then in use could be sustainable without revision. Discussion among the Curriculum Committee and Assessment Committee led to identification of primary, secondary, and tertiary tools based on which of the assessment tools in 2006 were most informative, which had some utility, and which could be reserved for occasional use when needed. For the 2006-2012 assessment cycle, the prime tools were trimmed to six, retaining the two direct measures and the most quantitative of the indirect measures. Another 5-6 tools were selected as useful for identification or confirmation of trends. These measures were also evaluated to decide what frequency was most appropriate for each tool. Some were chosen for continued application each semester, while others were naturally appropriate for an annual cycle. Several of the performance indicators were chosen for application every 3-4 semesters. More detail on the current assessment application procedure and future changes under consideration is presented in Criterion 4 in sections 4.B. and 4.C.

H. Joint Accreditation

The program seeks accreditation for a degree in Chemical Engineering from the Engineering Accreditation Commission (EAC) of ABET alone. It is not jointly accredited.

CRITERION 1 – STUDENTS

1.A Student Admissions

This section is divided into subsections that summarize the requirements and processes for accepting new students into 1) the University of Wisconsin-Madison, 2) the College of Engineering, and 3) the Department of Chemical and Biological Engineering.

1.A.1 University Admissions Requirements and Processes

To be considered for admission to the University of Wisconsin-Madison as a freshman, students must complete a minimum of 17 units of high school course work, including 4 units of English, 3 units of math, 3 units of social studies, 3 units of science, 2 units of a single foreign language, and 2 units of additional academic/fine arts.[1] On average, admitted students exceed this minimum by a five-unit margin. Currently, students admitted to UW-Madison in the midrange (25^{th} to 75^{th} % in the entering class) have a high school grade point average (GPA) in the range of 3.5 to 3.9 and a class rank between the 85^{th} and 96^{th} percentile. American Collegiate Test (ACT) scores for midrange admitted students are 27 to 30 while Scholastic Aptitude Test (SAT) scores are 1760 to 2090 (numbers from College Board).

Admission to the University of Wisconsin-Madison is competitive, and many variables are considered in addition to the coursework requirements, GPA, class rank, and college test scores. Admissions counselors here consider such qualities as leadership, community service, creativity, talent, and enthusiasm; they also look for other personal characteristics that will contribute to the diversity of the university. Students are required to submit an application, a written statement responding to two questions, official transcripts from high school coursework, and official College test scores from either the ACT or the SAT. It is suggested that they also submit two or three letters of recommendation from teachers, mentors, or employers who are familiar with their abilities, work habits, and character.

Students may apply in fall or in spring for UW-Madison. UW undergraduate admissions counselors are assigned particular regions of the state, country, or the world, and all applications are reviewed and ranked; annotated student profiles are created for each. All applications are reviewed by at least two different admissions counselors; typically, after two reviews, some students are admitted, some students are denied admission, and some are "postponed." A postponement may happen particularly for students who apply in the fall of their senior year of high school: sometimes it simply indicates that the student is likely to be successful if admitted, but the admissions counselor is waiting to see how many applications will come in for the spring, as they are concerned about capacity; sometimes they are simply waiting for mid-semester grades in AP courses to make a decision on some applicants. Before the end of March, a third admissions counselor will review those students on the postponement list, and decisions will be made. If a student is denied admission, s/he can write an appeal and ask for review. Overall, 50 to 55% of the students applying to the UW-Madison are admitted.

UW undergraduate admissions counselors have observed that the number of students declaring an interest in the College of Engineering has gone up over the past several years, perhaps in response to both the good reputation of our engineering programs and in response to the

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[1] A unit corresponds to one year of coursework.

challenges of our current economy, where technical jobs are viewed as having more potential. When students indicate an interest in engineering on their application form, they are routed to the engineering Student Orientation and Registration summer program.

1.A.2 College of Engineering Admissions Requirements and Processes

When students come to campus for the summer Student Orientation and Registration (SOAR) program, they indicate whether they are interested in a particular field of engineering, or whether they are undeclared. All new students admitted to the College of Engineering but not yet admitted to a degree-granting department are assigned the general engineering classification of EGR, and they are assigned an EGR advisor depending on the field of engineering that they are interested in. EGR students should transfer to a degree-granting department as soon as they are eligible; students must meet requirements for admission to a department within their first four semesters of attendance. Students may not begin a semester with the EGR classification once they have completed four semesters in residence as an EGR student (Summer session is not considered a semester).

All undergraduate engineering students must complete all six of the General College Requirements (GCR) to be considered for admission to a degree-granting classification in the College of Engineering:

1. completion of the General Education Communication Skills Part A requirement.
2. a minimum of 24 degree credits.
3. a minimum of 17 credits of calculus, statistics, chemistry, computer science, statics and physics courses required for an engineering degree. These credits must include Math 222 or Math 276.
4. a grade point average of at least 2.50 for all math courses 217 and above, statistics courses 224 and above, chemistry (all classes), computer science (302 and above), EMA 201, and physics courses 201 and above, not including independent studies and seminar courses. For one and only one of these courses that a student has repeated, the more recent of the two grades will be used in the calculation.
5. a grade point average of at least 2.00 for all courses not included in Regulation 4.
6. successful completion of introductory chemistry (Chem 103/104 or 109 or 115); calculus-based mechanics (Physics 201, 207, 247 or EMA 201); math through Math 222 or Math 276; and InterEGR 101 or 160 or another introduction to engineering class from an approved list. (The introduction to engineering requirement may be waived for transfer students).

Students can apply before their fourth semester if they have fulfilled all of the above requirements, but it is their responsibility to apply by their fourth semester. Normal application periods are September 1 through November 1 for Spring semester admission, and January 15 to March 1 for Fall semester admission.

1.A.3 Processes followed by the COE Undergraduate Admissions Committee

When the number of applicants meeting the GCR requirements exceeds the capacity of a particular degree-granting program, the COE Undergraduate Admissions Committee must meet with those programs and make decisions about which students can be admitted. In order to implement the University's goals of maximizing the success of students who are admitted to a program and of achieving a heterogeneous and ethnically diverse student body, decisions about student admission to programs operating at capacity are made based on grade point averages, test scores, geographical and personal background, and diversity. The COE admissions committee considers students from the following different groups: EGR students who have written an appeal after being denied admissions in the previous semester, EGR students in their fourth semester, students interested in engineering who are transferring in from a different university or college, other COE students who are not yet in their fourth semester, and Letters and Science students hoping to transfer into Engineering. None of these groups is necessarily given priority over the others; instead, students are chosen from each group to maximize the success of the students admitted to a particular program.

The COE Undergraduate Admissions Committee meets each semester to make these decisions about which students to allow into programs. In Chemical and Biological Engineering, one or a few faculty members participates fully in these Admissions Committee meetings. They examine DARS records, any other materials in their student records, ethnicity and gender, and any other materials supplied by the student. All of these materials are considered on a case-by-case basis as decisions are made for admissions into each program. The CBE department has been operating under enrollment management since 2009, because student demand for the major exceeds capacity. When difficult decisions must be made between EGR students, students who are transferring into UW, or students transferring into the COE from other Colleges on campus, priority may be given to students who are EGR students with a proven track record in our courses. (Please see section 1.C below for more detail about how transfer students are admitted.) The committee reviews close cases until they have a consensus decision.

Students denied admission after their fourth semester may reapply a second time, and if they are denied admission after their second application, they can file an appeal with the Dean. At this time most recent grades for any engineering courses and any off-campus courses, if taken, will be considered, especially if there are extenuating difficult circumstances that may explain weak performance in earlier coursework. Typically, students who are denied admission have already spoken with the EGR undergraduate advisors, and the news does not come as a surprise. If they are not admitted to the engineering program to which they applied, they are encouraged to consider other engineering programs that are not yet at capacity. Some COE programs reach their capacity before others, and sometimes students decide to go into a branch of engineering related to but not exactly the same as the field that initially interested them. Sometimes they also decide to go elsewhere, for example, they may change their major to Chemistry or Computer Science.

COE is facing a challenge due to the increased enrollments at the freshman level: once those students are ready to apply to specific programs, capacity can become a serious issue. Today more programs are reaching capacity, and the College is working on best practices for managing those capacity levels. The stated capacity for each department is shared with the COE undergraduate admissions committee, and those stated capacities hinge on faculty workload and course capacity. With increasing enrollments and decreasing state funding, the COE has been using differential tuition to manage capacity issues in several programs. The admissions committee and the deans are in conversation with the departments about innovative ways to increase capacity.

1.B Evaluating Student Performance

All undergraduates are subject to College of Engineering rules for minimum academic achievement and progress toward degree. All students must earn at least a 2.0 GPA each semester, and must pass at least 12 credits per semester, or they are placed on academic probation. Once on probation, a registration hold is placed on the student's record and he or she is required to meet with his or her academic advisor to discuss the consequences of academic probation and ways in which to improve his or her academic standing for the future. (The Chemical and Biological Engineering Department places a registration advising hold on all students every semester, whether or not the student is on probation. The advising hold is cleared after the student has met with his/her advisor.) To clear probation, a student's cumulative and term GPA must be at least a 2.0; he or she must pass at least 12 credits in the semester immediately following placement on academic probation, and must have passed at least 24 credits in the two most recent semesters in residence (not including the summer session). A student on probation who does not meet these standards is academically dropped from the university, and must apply for re-admission. The Office of the Registrar assists in maintaining these standards by providing the COE with spreadsheets showing end-of-semester actions (probation, dropped, deans honor list) for all registered engineering students. All communication in this regard was recently revised to address student concerns about the clarity of the process.

Effective in the Fall 2011 semester, students are required to take all courses that count toward their degree for a letter grade. Prior to this decision, students in the COE were allowed to take two Liberal Studies electives as pass/fail (excluding the courses in Environmental Studies and/or Economics that a few departments require). The purpose of the change was to respond to reports from course instructors in the College of Letters and Sciences that engineering students were not taking the ethnic study component of their education as seriously as they should and that engineering was the only school that allowed the pass/fail option. The COE Academic Planning, Curriculum, and Regulations Committee (APCRC) discussed these concerns and the relevancy of liberal studies courses in engineering education with consideration of feedback from industrial advisory boards and employers. It was decided to remove the pass/fail option not only from the ethnic studies campus-level requirement but also from all required liberal studies courses. This motion was taken to the College of Engineering Academic Planning Council and passed unanimously with the provision to implement the change as soon as practical. Students may continue to take other courses on campus on a pass/fail basis, but these courses cannot be used to fulfill any degree requirements.

For undergraduates in the College of Engineering, GPA and course progression are the primary, direct performance measures used by advisors to monitor and evaluate student progress in each program, but faculty and staff use a variety of methods to provide feedback and thus encourage student progress. Course instructors discuss class work performance with each student and help students understand its relation to subsequent courses. Students participate in student-led organizations with faculty advisors to provide them feedback, and students often work in research labs where faculty supervisors provide feedback on student performance. Students in the program are required to have contact with their advisor each semester. This requirement is implemented by placing an Advisor Hold on every CBE student in the month before registration opens for the following semester. Holds are removed after students have an office visit or satisfactory advisory email exchange with their assigned advisor or an alternate. Advisors and staff in the Engineering Career Services program help students understand their career goals and make choices that will build their professional credentials.

1.B.1 Using the DARS Tool for Monitoring and Documenting Student Progress

Because engineering curricula are structured and require a large number of specific courses, it is particularly important that engineering students work closely with engineering advisers to monitor progress toward graduation. An indispensable tool for tracking progress toward degree requirements is the Degree Audit Reporting System (DARS). DARS is a computer program that contains all student transcript information and provides output of a student's record of classes taken and credits earned mapped against particular degree requirements within a program. Thus, while the transcript is a chronological record of student work, the DARS is organized functionally and is more straightforward for use in evaluating completion of degree requirements and also in recognizing sequences of prerequisites or related coursese. Students and their advisors can obtain a DARS report at any time through their individual My UW web portals; students are encouraged to check their DARS at regular intervals to ensure that they are making satisfactory progress toward their degree.

Students work closely with an adviser to make sure that DARS accurately reflects courses taken and applicable degree requirements. DARS becomes particularly important as students approach graduation. A DARS report showing all requirements satisfied is mandatory before a student can obtain a B.S. degree. DARS printouts will be provided to accompany transcripts of all students selected for pre-visit compliance testing by the ABET Program Evaluator.

Another tool utilized by students and advisors to monitor progress is the EAGLE course planner system. The system was originally developed for the Department of Mechanical Engineering in Fall 2009 and in Fall 2010 it was expanded to all departments. EAGLE is an easy-to-use, visual tool that can be used to plan and monitor student academic progress. In its simplest terms, EAGLE is a visual flowchart (e.g. visual DARS) that indicates the graduation requirements which have been met, as well as those yet to be fulfilled. In addition to allowing students and advisors to monitor progress, it allows departments to estimate the number of students in the major who are planning to take each course. A sample EAGLE printout is included in section 5.A.4 illustrating the prerequisite sequence. The EAGLE tool provides an useful overview but is not a rigorous method of checking for satisfaction of liberal electives and other more complex degree requirements.

1.B.2 Monitoring Pre-Requisites for Courses

Students are responsible for checking the curricular flow charts provided in program brochures and websites; these flowcharts will make clear which courses are pre-requisites for others in the curriculum, and the flowcharts will often include suggestions and a recommended order of courses even if there are no official pre-requisites for a given course. For courses that have official pre-requisites, in the past few years more of these pre-requisites are being programmed directly into the online Integrated Student Information System (ISIS) through which students register for courses. Since enrollment in the College of Engineering has been increasing every year since 2006, we have seen increased pressure for some high-demand courses, and it has become imperative that the seats in those courses be reserved for students who are well prepared. Thus, students who do not have the pre-requisites may now be blocked from registering for some courses. The Chemical and Biological Engineering department uses the ISIS system to block students who do not have pre-requisites for key, selected courses. Enrollment in these capacity-limited courses in the department is managed by the Undergraduate Student Examiner. The online catalog listing for the entry courses (CBE 250 and 255) and the laboratory courses (CBE 324 and 470) indicates that space limitations result in registration priority for students within the major, and invites interested students to request a seat in the course from the department. The Undergraduate Student Examiner enters registration authorizations in specific sections first for CBE students who have satisfied prerequisites for the courses, then authorizes registration for students in other majors who need the course and have suitable academic backgrounds. Other CBE courses with prerequisite CBE courses are discussed between students and advisors in the regular advising meeting and advisors check for prerequisite satisfaction then. To a great extent, the CBE courses are so strongly sequenced that they enforce their own in-department prerequisites automatically.

1.B.3 Substituting courses for official degree requirements

Students are allowed to request course substitutions for courses taken which are not listed as fulfilling their degree requirements, subject to the following regulations

1. Any student may, with advisor approval, replace up to 12 credits of required courses in the curriculum (except CBE 424) by an equal number of credits of other courses within the restrictions listed under (3).
2. Any student who wishes to amend the curriculum by more than 12 credits or wishes to appeal the advisor's decision in (1) or to request exception to (3) below must submit a written request to the chairperson of the department, who will bring it to the department faculty for consideration.
3. Restrictions on course substitutions are the following:
    - Physics courses may be replaced by science or specific engineering courses;
    - Chemistry/life science courses must be replaced by courses with significant chemistry/life science content;
    - Engineering courses must be replaced by engineering courses;
    - Lab courses must be replaced by an equal number of hours of lab courses;
    - English 101, English as a second language courses, and Math 112-114 may not be used for course substitutions.

Students requesting a course substitution must complete a Course Substitution form. The substitution must be approved by the student's advisor, who indicates approval by signing the Course Substitution form. All course substitutions approved by advisors are then reviewed by the department's curriculum committee chair.

Substitutions approved by the department must also be approved by the College of Engineering Academic Policies, Curriculum, and Regulations Committee (APCRC) before being formally accepted. That committee meets monthly during the academic year to review DARS substitutions.

1.B.4. Substituting study abroad courses for official degree requirements

UW-Madison engineering students participating in International Engineering Studies and Programs (IESP) abroad must obtain approval for each course taken abroad. Each course must be assigned a UW-Madison "equivalent" course in order for grades and credits to be recorded on the student's UW-Madison transcript.

Students considering studying abroad review IESP's established course equivalency lists and credit conversion scales for the specific overseas university or program site (these equivalency lists are available at the IESP website). Several study abroad units on campus send UW students to the same institutions UW Engineering students attend, and IESP recognizes courses that have already been approved through these other campus offices. Students can check the equivalency lists for these programs to see if any courses from the study abroad institution have been equated through these other offices:

1. International Academic Programs (College of Letters & Science)[2]
2. International Programs (School of Business)[3]

These lists contain approved courses taken by previous study abroad participants from UW-Madison.

If the course a student desires to take abroad is already on one of these approved lists, the student submits a Course Declaration Form at least four weeks into their study abroad program. This form confirms the courses being taken overseas and provides IESP with additional information for processing the overseas transcript. If the courses selected already have approved equivalencies, students do not need to submit any additional documentation beyond the declaration form, which will show the number and title of the course abroad, the number and title of the equivalent UW course, and a checkbox indicating that the course was pre-approved.

However, if the courses selected at the host institution do not have pre-approved equivalents, students must work with their departmental advisors and the IESP office prior to their departure to obtain these new equivalencies. First the students must obtain a course syllabus (or detailed course description) for the desired study abroad class. The syllabus/description MUST include the following: a list of prerequisites (if any), a bibliography of texts/articles that will be used for the class, and the form of evaluation (i.e. projects, quizzes, exams, exercises, etc.). If at all possible, students should complete this part of the process prior to departure. Students may consult with the department's International Studies Advisor, who may recommend equivalent courses in the department or in other departments, and also helps students identify suitable supporting documentation for the course equivalency request. It is the student's responsibility to look for an equivalent course at UW-Madison and contact the department here that offers the equivalent course to request that faculty review the equivalency request. If the faculty or instructor of record for the course determines that the course is equivalent, he or she will then fill out a Course Equivalency Request Form. The syllabus for the proposed study abroad course

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[2] Consult the list of courses for each program by visiting the program page at http://www.studyabroad.wisc.edu/programs/index.asp

[3] Found at http://bus.wisc.edu/degrees-programs/international-programs/participants/course-equivalencies

must be attached to the form. If no corresponding course is identified, the International Studies Advisor may determine if the study-abroad course would be suitable as an elective course in the department, and then the Advisor may approve the substitution. Once a decision has been made, the completed and signed form is returned to IESP for processing.

Approved courses are added to the list of approved equivalencies for the respective program. Each COE program has an existing list of approved equivalencies that can be accessed at the International Engineering Studies and Programs website; that website also provides more detailed information on the Course Equivalency approval process.[4]

1.B.5 Indirect measures of student progress toward the degree

Engineering Career Services, the Student Leadership Center, and the International Engineering Studies and Programs staff are instrumental in monitoring the progress of students. These units provide resume workshops, individual consultations on resumes, mock interviews, leadership consultations with student organizations, study abroad fairs, and cultural orientations, along with a host of other services that afford staff a chance to monitor student progress and provide feedback. Their guidance helps students make appropriate choices that enhance their academic productivity and professional skills. In turn, these staff also can keep faculty advisors informed about student morale or problems in particular courses.

Another way that the College monitors progress of its undergraduates is through the academic support services offered in engineering's Wendt Commons, where regular Supplementary Instruction and tutoring services are offered. Feedback from SI tutors and study group facilitators can help monitor the progress of students in key courses.

The COE is vigilant regarding the health, well-being, and academic success of its students. Faculty and teaching assistants are encouraged to refer students who are not thriving to the COE Counselor, David Lacocque, who is part of the UW-Madison Counseling Center at University Health Services (UHS). Dr. Lacocque has developed expertise in the nature of the stresses encountered in an academically rigorous professional program. In addition, instructors and student services specialists refer students to academic deans if they notice unhappy or unhealthy students.

1.C Transfer Students and Transfer Courses

Students transferring from other institutions directly to COE degree-granting programs may come from other UW campuses in the state or from other universities and colleges in the state, nation, and world. Students must complete the curriculum requirements in place at the time of their admission to a degree-granting program. To ensure that engineering transfer students coming from other institutions achieve the outcomes of the programs that they enter here, the COE Transfer Admissions Coordinator reviews transcripts and notes gaps in course content. Course substitutions for similar courses already taken as part of a previous major are accepted

[4] Further information about course equivalencies is available through International Studies and Programs: http://international.engr.wisc.edu/preparing/courseequivalencyprocess.php

provided the substituting course achieves the educational outcomes of the required course. Decisions on cases for course substitutions that are not clear cut are the purview of the Undergraduate Associate Chair, the departmental faculty and/or the departmental curriculum committees.

The College of Engineering relies on state-wide transfer guidelines established by the UW System and participates in three articulation programs to facilitate a smooth transfer and transition to campus. One such program is UW-Madison Connections, which offers dual admission for 18 UW-System campuses and four Wisconsin technical colleges. Connections students who also meet the COE admission requirements can transition directly to an engineering degree program here at UW-Madison. In addition, the COE has established two other programs that guarantee transfer admission: the Dual Degree Program (with fourteen four-year institutions) and Engineering Transfer Blueprint (with Madison Area Technical College).

To be considered for transfer admission to an engineering degree-granting program, students must meet two sets of expectations: general transfer admission requirements as established by UW-Madison *and* additional requirements set by the College of Engineering.

First, students must meet the UW-Madison general transfer admission requirements, which include the following: High school course work must have included one year of algebra, one year of plane geometry, one year of college-preparatory math, and two years of a single foreign language in high school or two semesters of a single foreign language in college. At least 24 credits of transferable college-level course work (not including AP or other test credits) are required. The overall academic record is considered, including rigor of college course work, course breadth, and grade trends and patterns. Nonacademic factors such as extracurricular activity, employment, and community service may also be considered. Academic achievement, however, must have priority to help ensure a successful transition to this campus. Most transfer students must have at least a 3.0 cumulative GPA on a 4.0 scale. All grades are included in GPA calculations, including the first grade for any repeated courses.

Second, to be considered for admission to any degree-granting program within the COE, transfer students must meet the same departmental admissions requirements as those for students who entered UW-Madison as freshmen (see section A.2 for those requirements). Because admission is based on capacity, students who meet the minimum requirements might not be admitted. A strong match between transfer students and their engineering program of interest is desired. In the transfer application statement section or in a separate attachment, applicants are asked to explain their interests and goals, relevant experiences if any, and reasons for transferring here to pursue their intended program. They may also explain circumstances that may have affected their academic record. At least one letter of recommendation attesting to academic ability is required.

The transfer admissions coordinator in the EGR Office of COE determines acceptance of credits taken at another school, using the UW-Madison transfer equivalency databases. If a course is not in the transfer equivalency database, a transfer student may still petition to have the course considered for a transfer. In that instance, the transfer admissions coordinator consults with engineering faculty who can attest to the equivalency of transfer courses in terms of content and rigor to courses at UW-Madison. Courses must have at least a C final grade (2.0 on a 4.0 scale) for the credits to count for engineering degree credit. An institution must be accredited in order to transfer credit.

During each of the last six years, 4 to 17 students (3-16% of total students admitted) have transferred directly into Chemical and Biological Engineering from another institution. Other students who transfer from another college into the pre-engineering EGR status before applying for admission to the program. Students transferring into the college or the program must satisfy all of the requirements that our regular EGR students must meet. More specific data on our transfer students can be provided at the on-campus visit.

1.D Advising and Career Guidance

1.D.1 Academic Advising

The College of Engineering (COE) encourages students to seek guidance from multiple sources throughout their undergraduate studies. Just as no one mentor can fulfill all of a developing professional's needs, no one advisor can fulfill all of a student's needs. A student will receive richer and more valuable advice by seeking that advice from multiple advisors. Advising resources are distributed between the College Administration and individual departments.

Advisors in the Engineering General Resources provide on-going information and advice to students beginning with their first visit to campus (from high school) and coordinate recruiting efforts with advisors in the different programs in the College. Incoming freshmen, transfer students, and their parents attend the Student Orientation, Advising, and Registration (SOAR) program during the summer preceding matriculation. At their first day of SOAR, all students are assigned an individual academic advisor from the Engineering General Resources (EGR) office. SOAR provides an opportunity for entering students to meet with advisors to plan academic programs, register for classes, learn about university resources and campus life, and meet other UW students, faculty, and staff. Beyond SOAR, EGR advisors counsel students during their first two years of coursework in the COE, helping students make course choices that meet their interests and/or requirements for their engineering department of interest, informing students about supplementary instruction and other learning opportunities, fielding questions about majors inside or outside of engineering, answering career planning questions, or providing referrals for non-academic problems.

When students are admitted to the degree-granting program, they are assigned to a faculty advisor in the department. Within Chemical Engineering, undergraduate advising is a department-wide activity. Nearly all faculty members serve as academic advisors (314 students divided among 14 faculty) for a student to faculty ratio of 22. When students are admitted to the major as freshmen or sophomores, they are assigned to one advisor for the duration of their undergraduate stay, ensuring continuity in the process. Before 2009, students were assigned based on alphabetical ranges allocated to each advisor. Recently the advisor assignment process was changed to allow new students to use field of expertise or any other personal preference to select an advisor from the list of the faculty serving as advisors. This change results in increased opportunity for students to get career advising relevant to their particular interests from knowledgeable faculty. Newly admitted students without a preference are assigned based on balancing the current advising workload. Students are required to meet with their advisors at least twice annually, but many meet more frequently. The advising requirement is enforced strictly by placing advising registration holds on all students, which are lifted after students have met one-on-one with their advisors. (Email-only contact is allowed, but in-person meetings are strongly preferred.) The Department schedules a mandatory advising week mid-way through each semester, shortly before the University's web-based registration system opens for the following semester. "Advising holds" remain on the registration of non-complying students who have not communicated with their advisors. More general professional and career advising also occurs during this week, or by email or appointment throughout the year. Additional career information is available at the Engineering Career Services (ECS) office, which maintains extensive files on the many companies that interview here.

Extensive pre-advising activities ensure that students are knowledgeable on entering the program. The Student Status Examiner provides on-going information and advice to students beginning with their first visit to campus (from high school) and coordinates recruiting efforts with the dean's office. At these meetings, prospective students are given COE freshman handouts, the Chemical and Biological Engineering Student Handbook (curriculum guide with degree requirements), the Undergraduate Catalog, and other information of interest. Incoming freshmen, transfer students, and their parents attend the Student Orientation, Advising, and Registration (SOAR) program. SOAR is held during the summer before matriculation and provides an opportunity for entering students to meet with advisors to plan academic programs, register for classes, learn about university resources and campus life, and meet other UW students, faculty, and staff. Other SOAR sessions for transfer students are held throughout the year.

In fall 2011, the department began a new initiative to ease the transfer from EGR to CBE status. Several small-group advising sessions are scheduled at the beginning of each semester, and students newly admitted to the department are expected to attend one session. Typical attendance at these sessions ranges from 5-20. At the advising session, students are interested to the Student Status Examiner and the Undergraduate Associate Chair. The Associate Chair describes the curriculum flow, works with students to sketch out a plan for graduation, and explains how students can become involved with diverse opportunities such as undergraduate research, co-ops, international studies, and engineering student organizations. Contact information for counseling and other services is provided.

Email and web access have greatly improved communication between faculty and students. Email has proven to be a convenient method for handling much of the specifics of curriculum requirements and preserving more time for professional conversations with students. The Student Status Examiner sends all CBE students an advising form by email just prior to the academic advising period, and faculty advisors also inform advisees of their advising meeting schedule. Students fill in the advising forms and return them by email. Faculty advisors review the proposed list of courses for the next semester and raise any questions or concerns before the advising meeting. A copy of the completed student form is automatically forwarded to the undergraduate office, which allows advising support staff to review and answer many questions. Both students and faculty are pleased with the impact of email on advising. We have found that email increases student access to advisors and to the staff coordinator throughout the advising period and during the rest of the semester. Furthermore, this mode of operation allows advising meetings to focus on broader questions such as career choice or graduate school versus industry, rather than on routine administrative details.

The World-Wide Web has become an increasingly important tool for communicating with undergraduate students. Both of the CBE Student Handbooks with curricula (2 sets, applicable to students with different start dates [2007 and 2009] in the program) are available on the web. The same handbooks are also available in hard copy form at the office of the Student Status Examiner. Information on opportunities – internships/co-ops, community service, available research projects, student groups, and events both on and off campus – that will further their education are available to students on the web and via email messages and postings from the undergraduate office. We have made registration more convenient by allowing students to pre-register for CBE 250, 324, 470, and 424 on web pages. Assignments to the different lectures and labs are announced by email and in postings prior to registration week. Use of these technologies has greatly facilitated contact between faculty and students.

In the department, the DARS audit (which is described in section B) is used by faculty advisors to assist in the advising process. Advisors and students can do "what if" requests on other degree programs to see how the student's courses might fit into a prospective program. DARS takes the "guess work" out of selecting courses for future enrollment. The report informs both students and advisors what courses have been completed and what courses still need to be taken. Since DARS uses the on-line student record to get its data, the course data provided to DARS is up-to-date.

Much useful advising also takes place in the introduction to engineering classes (e.g., InterEgr 101, InterEGR 102, InterEGR 160, and EPD 155). The first-year courses introduce students to the different disciplines in engineering and enhance their awareness of available certificates, student organizations, and course choices that can develop their particular engineering interests.

In 2009, the COE co-located the Diversity Affairs Office together with the advising units to better assist student who are underrepresented in engineering (women and underrepresented minorities). The groups hold joint weekly meetings and meet informally about students they share in common. These interactions help Diversity Affairs Office staff to better understand the curriculum and requirements of the COE and also helps academic advisors better understand the challenges faced by underrepresented students. This is especially helpful when students face serious challenges and barriers to their education.

Undergraduates are advised in broader matters by specialists in the Engineering Student Development program, which houses Engineering Career Services (ECS), International Engineering Studies and Programs (IESP), and the Student Leadership Center (SLC). The professional staff in the office of Engineering Career Services help students to find internship and cooperative education positions as well as full-time employment. They advise students on all aspects of career development and train them on practical topics such as interviewing skills, résumé writing, and negotiating job offers and salaries. Students can become lifetime members of ECS by registering and paying a one-time $20 fee. Twice a year, ECS coordinates a career fair that brings literally hundreds of prospective employers to campus to meet and interview students. The vision of this office is to provide the students with lifetime tools for successful career development in a rapidly changing world.

The staff in International Engineering Studies and Programs advises students in study abroad opportunities, matching their career interests and curriculum needs to college courses worldwide. Students can use their study abroad opportunities to make progress toward their degrees or to explore additional academic areas while developing their skills in a foreign language. A growing number of engineering students are taking their study abroad opportunity a step further and pursuing the Certificate in International Engineering, which requires further coursework in languages and culture of a chosen region. The objective of the IESP office is to prepare COE students for a successful career in international engineering while facilitating an international student exchange program that enriches the diversity of the COE.

The staff of the Student Leadership Center administers the annual Innovation Days Competition, assists with the COE Dean's Leadership Course, and advises the 55+ registered engineering student organizations. With respect to student organizations, the SLC strives to provide student leaders with the support and resources necessary to implement quality programs and events, by assisting with special event planning, budgeting and financial oversight, organizational development and more. In doing so, the SLC provides the COE student organizations with fundamental business acumen and the practical leadership skills they will need to succeed in student competitions and in industry. Beyond the SLC, many of the registered student organizations provide their members with formal and informal career advice; for example, Polygon, the Council that represents all engineering student organizations, holds an advising fair each semester at which student organization leaders help students with advising questions.

1.D.2 Career Advising

Primary career advising is through the faculty academic advisor. Improvements in advisor assignment and in staff advising for course requirements described above increase the opportunities for students to have more thoughtful conversations about prospects for career planning with their advisor.

Formal resources available to students for career advising are provided through the Engineering Career Services (ECS) unit. Students are encouraged to enroll with ECS and use their resources as they look for employment opportunities. The department feels that the many resources available in ECS will help the students find rewarding employment. In addition, the interviewing and employment data compiled by ECS are valuable to the department.

Career options and opportunities also are explored in the monthly meetings of the student professional society chapters (AIChE). Frequently speakers from industries that hire chemical engineers are invited to describe their professional activities and provide advice on what to do while at the University to prepare for a career in the featured industry. Often these speakers are alumni of the University representing major employers of CBE students.

It is noteworthy, however, that the satisfaction with career services and job placement indicated by the EBI survey tracks closely with the 5-year trends in both the number of professional employers on campus and the number of professional interviews available. The EBI surveys indicate a high level of satisfaction and consistently higher than our Carnegie Class Institutions.

1.E Work in Lieu of Courses

Students entering UW-Madison may be able to get college credit by successful completion of college-level coursework while in high school or courses taken as part of a dual-enrollment program, for high achievement on college placement exams, with some forms of military training, and for some forms of life experience in lieu of coursework.

The University of Wisconsin grants advanced credit for the successful completion of college-level course work while in high school. Students who take college courses prior to high school graduation will receive advanced credit at UW–Madison as long as the credit is: 1) transferable, 2) earned at an accredited college, and 3) listed on an official transcript generated by the college. To be awarded credit at UW–Madison, enrolling students must have their official college-level transcript(s) sent to the Office of Admissions. Students taking courses at a UW System school may consult the Transfer Information System (TIS), an online system that can help students determine exactly how credit will be awarded here for specific courses they have taken elsewhere in the UW System.

College credit can also be granted for high achievement on Advanced Placement, International Baccalaureate, and College-Level Examination Program exams. The University of Wisconsin participates in the College Board Advanced Placement (AP) Program and awards course exemptions and college credit to entering students with qualifying scores. Generally speaking, for students to receive credits toward specific courses at UW-Madison, they must have at least a score of 4 and in some cases a score of 5 for that subject on the AP and IB exams. For the CLEP exam, scores must be at least 65. Procedures to be followed for gaining college credit include having the exam agency send test results directly to the UW-Madison Office of Admissions.

UW–Madison welcomes applications from eligible veterans, active duty service personnel, disabled veterans, reservists, National Guard Members, and dependents with state and federal education benefit programs. The university will award up to six credits in military science for students who have completed basic training. If applicants have taken courses at the Defense Language Institute Foreign Language Center, up to 16 credits for sequential courses in foreign language may be accepted. In addition, UW will evaluate military transcripts for other possible transfer credit. In general, learning experiences at military schools are occupational in nature and therefore not eligible for transfer credit. Courses must be similar in nature to a course in our undergraduate curriculum and applicable to one of our academic programs to receive transfer credit.

As noted in the section about Transfer Students, UW-Madison has been developing its dual-enrollment program. Now in its tenth year, the UW–Madison Connections Program is a dual-admission program created to help relieve freshman enrollment pressure and keep more academically talented students in the state. In this program, students are admitted to both UW–Madison and a partner institution, completing their first two years at the partner institution and then transitioning as juniors to UW–Madison, where they finish their degree. In 2009, the Connections Program expanded its list of partner institutions from a set of Wisconsin two-year campuses to include five four-year UW System institutions. Connections students can now choose among 22 campuses throughout Wisconsin to begin their college career.

Students transferring into the COE occasionally petition to have life experience counted in lieu of coursework; this happens especially with returning adult students. These petitions will be considered as long as satisfactory competence in a given area can be proven. Typically, the Student Transfer Coordinator identifies the appropriate faculty member with curriculum expertise in the Department to which a transfer student is applying, and that expert tests the student's knowledge or interviews him/her to determine that there is indeed an appropriate level of skill in the subject that is being petitioned for "life experience." Cases in which work experience is counted in lieu of courses are rare, but when they occur, they are handled on a case-by-case basis.

1.F Graduation Requirements

Each program in the College of Engineering determines the number of credit hours required for graduation from the program. It is the student's responsibility to ensure that these graduation requirements have been met. All students should regularly consult the Degree Audit Reporting System (DARS) in conjunction with their advisor to ensure that all the following graduation requirements are being met:

- have fulfilled the published graduation requirements of that curriculum, with all substitutions formally approved, and have achieved a minimum 2.0 GPA overall.
- have a Point Credit Ratio (PCR)[5] of at least 2.0 for those semesters and sessions containing the last 60 credits taken at UW-Madison or for all credits taken at Madison if fewer than 60.
- have a departmental PCR of at least 2.0 for all courses taken in the degree-granting department that count toward graduation.
- have completed at least 30 credits in residence in the College of Engineering, including 15 credits of work in the degree-granting department.
- have completed the last two semesters in residence in the College of Engineering as a full-time student.
- have a GPA of at least 2.0 both for the last semester and also for the combined last two semesters.

Typically in the final year of study, students will contact the departmental Student Status Examiner, who will check the DARS of students who plan to graduate from the program that year. If the DARS shows that a student is deficient on required credits for graduation, the examiner will submit the problem to departmental faculty advisors to resolve. At the beginning of the final semester, the examiner checks the DARS again to ensure all problems have been addressed, and then submits a list of graduating students to COE Academic Affairs, where the DARS of every prospective graduate is double-checked. When the graduates are confirmed, the list is sent on to the UW Registrar's office and posted.

Second majors and Certificates also have well-defined requirements and their completion will also be documented on UW diplomas. Any students who choose to have a second major will make suitable arrangements with advisors and examiners in the secondary department. Typically the second department is in the College of Letters and Sciences; it is not possible to obtain a second major within the College of Engineering. Engineering students fulfill all of the University and degree requirements in their primary, engineering department. Common second majors include Chemistry, Mathematics, and Biochemistry, although many others are also

[5] The Point-Credit Ratio (PCR) differs from the grade point average in that it involves only those credits that count toward graduation and the related grade points. When a course is repeated, the credits and grade points earned only for the final attempt are included in the point-credit ratio.

chosen. Certificate programs usually require 16-25 credits of specialized work that may be partially completed within degree elective flexibility but usually require some extra course or project work in excess of the degree requirements. Each certificate program has an application form, tracking paperwork, and procedures for determining satisfaction of certificate requirements. Popular certificates and second majors are:

<u>Certificates</u> (full list of options at College Certificates page, http://studentservices.engr.wisc.edu/advising/degrees/certificates.html

- Technical Communications
- Japanese Studies for Engineering Majors
- Biology in Engineering
- International Engineering
- Integrated Studies in Science, Engineering, and Society (ISSuES)
- Environmental Studies
- Engineering for Energy Sustainability

<u>Second Majors (# in progress)</u>

- Chemistry (13)
- Biochemistry (2)
- Mathematics (2)
- Economics (1)
- Molecular Biology (1)
- Music (1)

An Honors in Research program is available for high-achieving undergraduate students who wish to be engaged in significant research projects spanning more than one semester. The research should be such that the student participates in the creation of new knowledge, experiences the research process, and makes a contribution so that it would be appropriate to include the student's name on scholarly publications resulting from the research. The research need not be an independent effort by the student, but can be participation in a larger team effort, as long as it meets the criteria above.

The requirement for admission to the Honors in Research program is at least two semesters completed on the Madison campus with a cumulative GPA of at least 3.5. The student identifies and obtains the concurrence of an appropriate professor to serve as his/her thesis advisor. The student submits a letter to the Chemical and Biological Engineering department chair requesting admission, stating the topic of his/her proposed research, and identifying the proposed thesis advisor under whose guidance he/she will be working. The topic should be appropriate to the major. A letter from the proposed thesis advisor supporting the application is also included.

Students register for credit in Honors in Undergraduate Research (CBE 489). Students may register for 1 to 3 credits per semester and complete at least 8 credits total. A grade of "P" (Progress) is assigned each semester until the student completes the senior thesis, at which time a final grade is assigned (based on research progress and the written thesis if completed). This becomes the grade for all credits taken in CBE 489.

A senior thesis worth 3 credits of CBE 489 is required. The senior thesis is a written document reporting on a substantial piece of work. It should be written in the style of a graduate thesis. The thesis advisor determines the grade that the student receives for the thesis. A bound copy of the thesis should be submitted to the Chemical and Biological Engineering department office.

The senior thesis is presented by the student to a committee in a publicly announced seminar. Interested faculty and students are invited to attend.

The "Honors in Research" designation, recorded on the student's transcript, will be awarded to graduates who meet the following requirements:

1. Satisfaction of requirements for an undergraduate degree in Chemical Engineering.
2. A cumulative grade-point average of at least 3.3.
3. Completion of a total of at least 8 credits in CBE 489
4. Completion of a senior honors thesis with a final grade of B or better.

Students who are interested in obtaining research experience that is not as in-depth as the Honors in Research program are able to register for CBE 599 (Independent Studies). Students arrange CBE 599 individually with faculty, and must obtain a professor's authorization before s/he can register for a specific section of CBE 599. Typically, undergraduates register for 1-4 credits of 599 in a given semester, carry out a research project under the guidance of a professor and graduate students or postdocs, and report their results via oral presentation and/or written report.

Students graduating from this program receive a Bachelor of Science in Chemical Engineering.

1.G Transcripts of Recent Graduates

Representative transcripts of recent graduates will be provided to the Team by arrangement in advance of the team visit. Corresponding DARS reports will accompany these to aid in analysis.

CRITERION 2 – PROGRAM EDUCATIONAL OBJECTIVES

2.A Mission Statements

Mission statements for the University, the College, and the Department reflect the range of interested constituencies served at the different levels.

2.A.1 Mission of the University of Wisconsin-Madison

The University of Wisconsin-Madison is the original University of Wisconsin, created at the same time Wisconsin achieved statehood in 1848. It received Wisconsin's land grant and became the state's land-grant university after Congress adopted the Morrill Act in 1862. It continues to be Wisconsin's comprehensive teaching and research university with a statewide, national and international mission, offering programs at the undergraduate, graduate and professional levels in a wide range of fields, while engaging in extensive scholarly research, continuing adult education and public service.

The primary purpose of the University of Wisconsin-Madison is to provide a learning environment in which faculty, staff and students can discover, examine critically, preserve and transmit the knowledge, wisdom and values that will help ensure the survival of this and future generations and improve the quality of life for all. The university seeks to help students to develop an understanding and appreciation for the complex cultural and physical worlds in which they live and to realize their highest potential of intellectual, physical and human development.

It also seeks to attract and serve students from diverse social, economic and ethnic backgrounds and to be sensitive and responsive to those groups, which have been underserved by higher education.

To fulfill its mission, the university must:

(a) Offer broad and balanced academic programs that are mutually reinforcing and emphasize high quality and creative instruction at the undergraduate, graduate, professional and postgraduate levels.

(b) Generate new knowledge through a broad array of scholarly, research and creative endeavors, which provide a foundation for dealing with the immediate and long-range needs of society.

(c) Achieve leadership in each discipline, strengthen interdisciplinary studies and pioneer new fields of learning.

(d) Serve society through coordinated statewide outreach programs that meet continuing educational needs in accordance with the university's designated land-grant status.

(e) Participate extensively in statewide, national and international programs and encourage others in the University of Wisconsin System, at other educational institutions and in state, national and international organizations to seek benefit from the university's unique educational resources, such as faculty and staff expertise, libraries, archives, museums and research facilities.

(f) Strengthen cultural understanding through opportunities to study languages, cultures, the arts and the implications of social, political, economic and technological change and through encouragement of study, research and service off campus and abroad.

(g) Maintain a level of excellence and standards in all programs that will give them statewide, national and international significance.

(h) Embody, through its policies and programs, respect for, and commitment to, the ideals of a pluralistic, multiracial, open and democratic society.

2.A.2 Mission of the College of Engineering

The College of Engineering has a concise mission statement:

College of Engineering Mission: To educate and prepare men and women to contribute as engineers and citizens through the creation, integration, application and transfer of engineering knowledge.

2.A.3 Mission and Vision of the Department of Chemical and Biological Engineering

The department mission and vision statements include the full range of research and educational activities of the Department at both the graduate and undergraduate levels, but are consistent with the program educational objectives for our undergraduate program given below.

Department Mission: To create, integrate, transfer, and apply chemical engineering knowledge.

Department Vision: To be a department of chemical engineering that:

- provides a balanced learning experience that includes the best research and instruction in the chemical, physical, biological, and applied aspects of chemical engineering;
- constitutes a stimulating learning community that includes a collection of faculty, students, and visitors whose interests and expertise span length scales from the molecular to the macroscopic;
- provides an effective learning environment that includes the staff, facilities, and equipment necessary to achieve the best learning experience and learning community.

2.B Program Educational Objectives

Our Program Educational Objectives are broadly stated, as is appropriate for the wide range of careers that our graduates will pursue, in industry, business, government, academia, and nonprofit institutions. The Department recognizes that our graduates will choose to use the knowledge and skills they have acquired during their undergraduate years to pursue a wide variety of career and life goals. We encourage our graduates to explore diverse opportunities for employing their chemical engineering skills.

These objectives are published on the Web, in combination with the supporting outcomes, connected to the department web site at http://www.engr.wisc.edu/che/abet.html. These objectives for our undergraduate program are consistent with the department mission and vision statements given above.

The curriculum prepares students for engineering work on chemical processes and products supporting Objective 1. The content of the curriculum provides the basic knowledge and

Program Educational Objectives: Whatever path our graduates may choose, be it a job, graduate school, or volunteer service, be it in engineering or another field, we expect our graduates to meet the following objectives:

Objective 1: Foundation. That they will exhibit strong skills in problem solving, critical-thinking, leadership, teamwork, and communication;

Objective 2: Impact. That they will use these skills to contribute to the various communities, both local and global, within which they work, live, and function;

Objective 3: Awareness. That they will make thoughtful, well-informed decisions regarding not only their personal life and career, but also the arenas within which they function professionally and exert personal influence;

Objective 4: Education: That they will demonstrate a continuing commitment to and interest in education (their own and that of others).

flexibility necessary to permit students to practice the profession of chemical engineering and to establish the foundation for subsequent specialization in a sub-discipline of chemical engineering or for graduate study in chemical engineering or other related fields. Objectives 2 and 3 are fostered through a combination of courses and interactions with the faculty and instructional staff, through freshman engineering courses such as InterEgr 102 – Grand Challenges and InterEgr 160 – Freshman Engineering Design, and through numerous opportunities for outside-the-classroom experiences. Courses such as CBE 424: Operations and Process Laboratory and CBE 599: Independent Study, expose the students to a variety of real world examples and exercises which inform and engender an understanding of the impact and role of chemical engineers in society and the broader communities. The liberal education component of our curriculum acquaints our students with the broad range of human endeavors in the arts, humanities, and social sciences. This component opens students' eyes to diverse cultural patterns and equips students to participate fully in the modern, diverse and globally-connected world and to make the ethical decisions necessary to contribute to society. Objective 4 is supported throughout the curriculum through fostering an understanding of the open-ended and constantly changing nature of engineering work. Examples and exercises requiring the student to develop independent learning skills are used throughout the curriculum. This is particularly emphasized in CBE 450: Process Design, CBE 424: Operations and Process Laboratory, and through optional co-op and research opportunities. CBE elective courses augment these courses resulting in development of not only an understanding of the necessity for ongoing learning, but also critical thinking skills.

2.C Consistency of Program Educational Objectives with the Institution Mission

The departmental program educational objectives are consistent with the mission and educational objectives of the University and the College of Engineering (COE). At the undergraduate level, the mission focuses on transferring chemical engineering knowledge. Integration and application of that knowledge are also important aspects of our educational approach. The Department seeks a balance of research and instruction in the undergraduate learning experience, consistent with the significant undergraduate involvement in many research and engineering activities and projects through independent study activities and student organization involvement. The Department fosters and promotes in our students the development of the breadth of "chemical, physical, biological, and applied aspects of chemical engineering" that must be included in the repertoire of a modern chemical engineer. Finally, understanding and describing phenomena on a broad range of length scales from molecular to macroscopic dimensions is indeed part of the power and excitement of the modern chemical engineering approach to solving problems of interest to society. The Department strives to provide a wealth of opportunities, both formal and informal, to the undergraduates in order to achieve a multi-faceted learning environment that promotes engagement with the faculty, student organizations and industry.

The program educational objectives are thus clearly consistent with the mission and vision statements of the Department, and also with the corresponding statements of the College of Engineering and the University.

2.D Program Constituencies

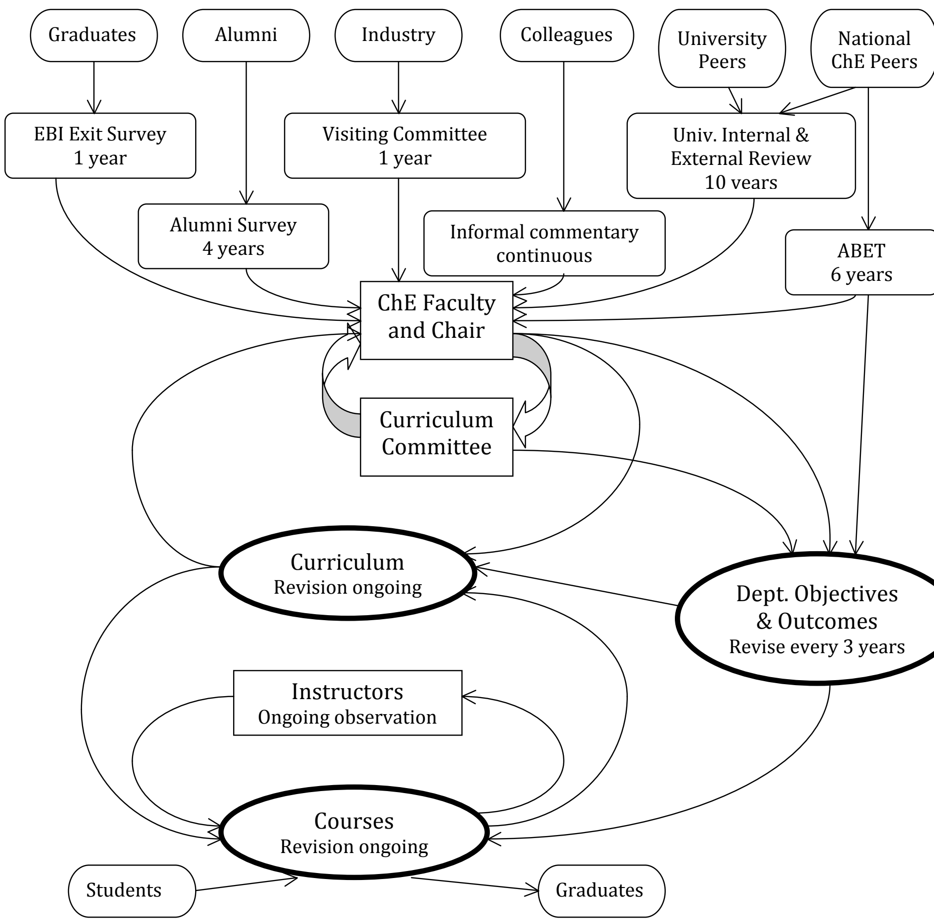
We have identified our B.S. Chemical Engineering alumni as the principal constituency of the Department. They are the main product of our undergraduate program, and they are the people most affected by the quality of the education they obtain. They will be using their undergraduate training and building on it for the rest of their careers. Section 2.E describes the process by which we obtain input from our constituencies.

Other significant constituencies include:

- Current undergraduate students – As the present audience of the program, they are the clients whom we are currently preparing for professional careers. Many of these students already recognize that the intellectually challenging courses we offer are an essential element of the foundation on which they will establish their careers as chemical engineers. In the words of a previous chairman from a commencement address, "Our goal is happy alumni, not happy students." We do not expect thoughtful input from the undergraduates on appropriateness of the PEOs; rather, we desire that they be aware of them and share them as goals and motivation for their studies. In any regard, communication with and feedback from our undergraduates is a valuable portion of our assessment and evaluation process.
- Industry – The companies that hire our students are another important client body. These companies constitute a heterogeneous and constantly changing group, with representation from Wisconsin, the Midwest, and the nation. This group involves companies in both the traditional chemical industry and many nontraditional fields. Some companies maintain a steady year-to-year presence on campus and consistently hire our graduates, while others come and go as the economy and industrial priorities change. Our alumni may have several employers during their professional lives, and may change directions more than once through their career. Thus, we are keenly interested in present hiring trends in the corporations now hiring our graduates, as well as the skills and backgrounds these corporations desire in their new hires. We also recognize the importance of providing our graduates with the basic education that will prepare them to confidently take on professional duties of ever increasing responsibility, either with their first employer, or with subsequent employers and instilling in them a recognition of the need for life-long learning.
- Academia and Professional Schools – A small but important fraction of our graduates continue their education by proceeding to graduate study in chemical engineering or allied disciplines, medical school, business school, law school, or other forms of higher education. Our undergraduates go on to attend many of the top graduate chemical engineering programs in the

nation, and are represented on chemical engineering faculty in other departments across the country.

- The State of Wisconsin – As the only chemical engineering program in the State, we provide the opportunity for students from the State to participate in the opportunities available in the CBE field. This is our service to the high-school students and families of the State, as well as to State industry. Perhaps unique to our State, the food industry and the pulp and paper industry of Wisconsin hire a significant number of our graduates, whereas the petrochemical industry in Wisconsin has only a minor presence. These industries are complemented by the strong and growing industrial sector in plastics and polymers, fine chemicals, biotechnology, and medical industries. While some students find employment in the State, many are employed out of state with large, national or international companies, providing nationally-based opportunities for the sons and daughters of Wisconsin residents to participate in high-technology activities.



2.E Process for Revision of the Program Educational Objectives

Review and revision of the program objectives is the initial responsibility of the Curriculum Committee, which brings recommendations to the faculty meeting for review and to receive suggestions from the faculty as a whole for improvement, and finally ratification and adoption. Throughout this process the PEOs may be discussed formally or informally with other constituencies through contacts with alumni, employers, and peers. The Visiting Committee is a particularly useful collection of representatives of these groups.

The program objectives are maintained and revised as necessary by the faculty of the Chemical and Biological Engineering Department. In formal meetings of the faculty, through informal discussions and weekly organized faculty lunch meetings, the CBE faculty consider the accumulated input from constituencies including alumni, corporate interviewers, and other outside contacts. These objectives describe our goal of preparing students to participate productively not only in the broadest possible range of chemical process industries, but also in related applications such as foods, pharmaceuticals, materials, and consumer and medical products, and even more broadly in business, consulting, and entrepreneurship. Specific lists of current technical fields of activity for chemical engineers would be both lengthy and unnecessarily limiting. An increasing percentage of our graduates are now employed by a wide range of "non-traditional" employers other than those in the petroleum, petrochemical, commodity chemical, specialty chemical, and pulp and paper industries that have historically have been the primary employers of chemical engineers. Consequently, this flexibility was chosen as the best way to include current and future growth areas. We anticipate that these objectives will not require frequent revision, but plan on returning to review the objectives and outcomes on a three-year (minimum) cycle to incorporate feedback from all of our constituencies and to ensure that the objectives and outcomes continue to be satisfactory. The Curriculum Committee will again direct any such revision.

The program educational outcomes have been periodically reviewed for possible updates or modifications. They were first adopted in 1999, and revised in 2005 to focus on the graduates in their first few years out of the program. Each recent review has determined that they continue to be appropriate in the current form. Through discussion at the departmental and COE levels and with input from our Visiting Committee, the college objectives were determined to be well – aligned with the departmental objectives and were adopted. These objectives are reviewed by the CBE Visiting Committee approximately every three years. Most recently, at the November 2011 Visiting Committee meeting we discussed the PEOs and once again obtained their endorsement of these objectives.

Based on available feedback from a variety of sources, as described above, no revision of program educational objectives is deemed necessary at this time. To remain current with these objectives, we engage in an ongoing process of revision of the curriculum and individual courses contained therein. We will review the curriculum and the objectives and outcomes, as noted above and in the following section.

CRITERION 3 – STUDENT OUTCOMES

3.A Student Outcomes

The student outcomes are reviewed and revised as needed to remain current and appropriate for program improvement purposes and for ABET compliance. The most recent changes were made in November 2011. As originally adopted in 1998, our existing outcomes reflected a grouping of professional, technical, and personal skills. The original set of outcomes represented a complete coverage of the ABET a-k list, but in a re-organized and non-unitary mapping. In 2004 we revised the list of student outcomes to reflect a more transparent correspondence with the ABET a-k listing in the use of generalized assessment tools and are more consistent with the ABET wording. The content and intent of the outcomes are largely unchanged but also reflects input from our program assessment in the intervening time. Outcome (c) was shortened by removal of the list of items "such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" after faculty discussion determined that this list of example constraint aspects could be implicit in the term "realistic constraints" for outcome evaluation use. Outcome (g) is overly concise and in practice is expanded to include coverage of different modes of communication in particular assessment tools. The clarification of outcome (l) in its new, form to include coverage of process hazards form was adopted by faculty vote in November 2011 after ABET approval of final wording for the change in Chemical Engineering Program Criterion. The current CBE

CBE Departmental Outcomes

Graduates from our baccalaureate program should have:

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

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

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

(j) a knowledge of contemporary issues

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

(l) ability to apply the basic sciences to the design, analysis, and control of chemical, physical, and biological processes, including the hazards associated with these processes.

outcomes a-k have a direct mapping to the ABET a-k listing, consistent with the current wording of ABET Criterion 3.

The Student Outcomes are documented for public access on the department pages of the college web site at http://www.engr.wisc.edu/che/abet.html. They are also included as part of the Student Course Evaluation form used at the end of each CBE course, so students see them each semester and have opportunity to reflect on their growth towards these goals. Results of the course evaluation are used for course improvement, instructor feedback, faculty promotion, and student outcome assessment. This is secondary, but does serve to create student awareness of the Student Outcomes and improves the quality of their responses in later semesters and on the EBI Senior Exit Survey.

Relation to ABET Criterion 3: The student outcomes map directly onto the ABET Criterion 3 a-k Student Outcome statements, so this relationship is satisfied *prima facie*.

3.B Relationship of Student Outcomes to Program Educational Objectives

The student outcomes provide a broad range of skills and background that together provide the foundation for our alumni to achieve the program educational objectives after they leave the university and begin the next stage of their lives. Specifically, Objective 1: Foundation will be supported by all student outcomes. Objective 2: Impact is fostered most greatly by outcomes e, f, g, h, i, and j. Objective 3: Awareness is supported by student outcomes f, g, and i and relates to an understanding by the student of the role of a chemical engineer. This can be additionally supported, outside of courses such as CBE 424 (Operations and Process Laboratory), through activities such as co-op experiences and student groups. Objective 4: Education specifically draws on student outcome i, lifelong learning, and the desire that our alumni apply this concept to themselves and those around them. Student outcomes h, j, and k also contribute to the preparation of alumni to achieve Outcome 4: Education.

	CBE Student Outcomes											
Program Educational Objective	a	b	c	d	e	f	g	h	i	j	k	l
Objective 1: Foundation.	x	x	x	x	x	x	x	x	x	x	x	x
Objective 2: Impact.					x	x	x	x	x	x		
Objective 3: Awareness.						x	x		x			
Objective 4: Education:								x	x	x	x	

The undergraduate curriculum in Chemical and Biological Engineering is designed to provide students with the background necessary to achieve all of our program outcomes. More detail on this is contained in Criterion 5 – Curriculum.

CRITERION 4 – CONTINUOUS IMPROVEMENT

4.A Program Educational Objectives

The program educational objectives are broadly defined to include the constantly evolving nature and scope of the discipline of chemical engineering. The program is designed by the faculty to achieve the educational objectives of the Department. Because the Department aspires to prepare students for careers in a constantly changing environment, the curriculum and the courses that constitute the curriculum must necessarily be continually evolved in response to feedback provided by various constituents. The assessment tools described below provide feedback from different constituencies and are implemented with varying frequency as outlined.

TABLE 4.A.1: Assessment Tools Used to Evaluate Achievement of PEOs

CBE Program Objectives → **↓ Principal Assessment Tools**	1. Foundation	2. Impact	3. Awareness	4. Education		Frequency
CBE Alumni Survey	X	X	X	X		3 years
ECS Recruiting and Placement Data	X	X				Annual
Visiting Committee Reports	X	X	X	X		18-24 months

Alumni Surveys – Thorough surveys of alumni representing all areas of chemical engineering practice have been conducted 5 times since 1996, with two surveys in each of the 6-year ABET cycles. The most recent survey is being conducted in 2012. The original survey was prepared in 1996 by the LEAD (Learning, Education, Assessment, and Dissemination) Center, a campus group established to assist academic departments seeking evaluations of educational impacts. In 1996, they developed a comprehensive survey that included numerous questions on issues of both general and particular interest to the Department, and also compiled results to produce a report summarizing the responses. The initial survey was sent to alumni 3, 5, and 15 years past graduation. Subsequent surveys have included only the 3-year and 5-year cadres of alumni to focus on these more recent graduates. The ratings and comments supplied by the respondents have been helpful in confirming the strengths of the program and in identifying areas where improvements are desirable. These survey results are stored on the CBE assessment website (http://www.che.wisc.edu/assessment/) and will be available in hard copy at the site visit.

ECS Recruiting and Placement Statistics – The student success rate in obtaining employment or admission to graduate programs is a good aggregate measure of whether the program holds realistic objectives and whether the graduates exemplify the objectives and outcomes. The Engineering Career Services (ECS) Annual Report contains statistics for each year on companies and students participating, number and level of salary offers reported, and percentage of students accepting an offer (employment or graduate school). Tracking trends in these statistics allows us to monitor both the employment market and how our graduates are received by industry. ECS data also allow us to identify companies that hire large numbers of graduates, helping us to make contact with interview team leaders to gain additional insight into strengths of our graduates and areas where further improvement is desired.

Visiting Committee – The department has a visiting committee composed of prominent industrial and academic chemical engineers who have met every 1½ years to assess the current state of the Department and provide advice on future directions. The committee members are selected for their professional perpectives and their interest in maintaining the high quality of undergraduate education in the department. Current members (and connection with UW CBE alumni) are as follows:

Michael Amiridis (PhD ’91) – dean of engineering at University of South Carolina.

William Banholzer – CTO of Dow Chemical; long involvement with UW as lead interviewer for GE, sponsor of Dow chemistry/chemical engineering research initiative at UW.

Doug Cameron – Director, First Green Partners; former member of UW CBE faculty, industrial positions with Cargill, Khosla Ventures, chief science advisor at Piper Jaffray.

John Church (BS ’88) – advanced through supervisory, plant manager, and product manager positions at General Mills; now VP for Procurement.

Tom Edgar – faculty at UT-Austin; collaborates with UW faculty through Texas-Wisconsin Control Consortium and visits regularly.

Jay Ihlenfel (PhD ’78)– Sr. Vice President/Asian Pacific, 3M Co.

Klavs Jensen (PhD ’80) – department chair at MIT; also interacts with UW alumni on faculty and among graduate students there.

Mike Jensen (BS ‘73) – recently retired from Proctor & Gamble as VP for research; tracking many UW alumni at P&G.

Abraham Lenhoff (PhD ’84) – faculty at Delaware; visiting Hougen Professor at UW.

Gary Pruessing (BS ‘75) – President, ExxonMobil Pipeline Co.

Richard Register (PhD ’89) – department chair at Princeton University.

Kate Stebe – dept. chair at Penn; interacts with UW alumni on faculty and among graduate student body.

The most recent meeting was held in November of 2011. Visiting Committee reports are based on both their forecasts for new needs and on fact-finding meetings with students and untenured faculty during their visits. While this committee is a conduit for insights based on the current state of the department, they also provide useful input on departmental impact from their working knowledge of the role of UW alumni (3-5-15 years out) in their professional spheres. They are exemplars of the long-term career development of more senior alumni on the 20-30 year timescale. They assess our undergraduate program through supplied materials, presentations, and interviews as well as through their independent concerns and experiences. The interactions between committee members and department faculty are particularly candid and provide important input. Comments in their reports concerning the strengths of our program and/or successes of our graduates generally validate the program objectives, program outcomes, and curriculum as a whole. Reports of the Visiting Committee are stored on the assessment web site (http://www.che.wisc.edu/assessment/) and will also be available for the site visit.

Additional secondary data sources

Interviewer Feedback – Corporate interviewers are often outspoken about the high quality of our recent alumni. They frequently provide anecdotal examples of productivity of newly hired UW graduates, and of how quickly these individuals advance to positions of responsibility. Even during times of slow hiring, many companies have continued to recruit at the University of Wisconsin. A number of large employers have placed UW on their "key school" list of top-priority interview sites while they are cutting back on interviewing elsewhere. This practice amounts to a commercial and fairly unbiased outside assessment of the entire program and its objectives. The lack of detailed, critical commentary in these conversations makes them less useful in identifying areas for improvement, so we have recently undertaken a survey of key corporate interviewers and interview team leaders at large employers of our graduates to obtain additional detailed commentary.

Alumni News – A steady stream of updates from alumni is received by the department, and this is useful anecdotal evidence as to how our graduates are attaining the different PEOs. Many of these updates are documented in our semiannual departmental newsletter, *On These Foundations*. These contain information on promotions, job changes, family events, and other instances of personal and professional growth and success. The "In Memoriam" column in the newsletter also reports career and personal accomplishments of newly–deceased alumni. Although it is recognized that self-reported news is not necessarily representative of all alumni careers, the overall rate of reports and level of accomplishments are still useful in demonstrating success of our alumni. Its decline would be quickly noted. Other alumni news is obtained at alumni meetings such as AIChE hospitality suites and through the several "Wisconsin Connection" regional alumni meetings that have been held recently in the Philadelphia area and the Minneapolis area.

Review Committees – Every 10 years, the University of Wisconsin requires each department to undergo an internal review (committee of UW faculty) and an external review (committee of Chemical Engineering faculty from other universities). Our most recent review is ongoing in the spring semester of 2012. These reviews focus mostly on strategic planning and cover both the instructional (undergraduate) and research (graduate) components of department activities. Both committees meet with undergraduates and have the opportunity to examine the priorities and impact of our undergraduate program. In the 2000 review, the external committee, in particular, commented favorably on the department's tradition of writing innovative and significant undergraduate textbooks and encouraged continued activity of this type as a service to chemical engineering educators across the country. The 2012 committee has completed information-gathering meetings with the department and is currently preparing its review report (as of 4/3/12).

The College of Engineering has an Industrial Liaison Committee that visits twice a year. This group represents employers and alumni from all college departments. They are also a source of perspective and advice when program assessment is placed on their agenda. Most recently, at the ILC meeting of April 6, 2012, we obtained useful comments for the college and some specific perspectives from the subcommittee focused on the department.

National Rankings and Reputation Measures – National rankings are an unsolicited assessment of our program quality and impact. Departments exercise no control over the criteria chosen; some rankings state no explicit evaluation criteria, and many faculty take issue with some of the factors included in other rankings. Even so, the Department has consistently placed in the top ten chemical engineering departments in the nation in rankings over the last decade. The 2011 *US News & World Report* ranking of undergraduate chemical engineering programs rated the Department as 6th behind the programs at MIT, UC-Berkeley, Stanford, Caltech, and Minnesota, and ahead of many other highly regarded departments. These assessments reflect favorably on the curriculum and the instructional standards of the Department. However, they are less useful in providing feedback for identifying improvements.

The *US News & World Report* undergraduate rankings are based 'solely on a peer survey of deans and senior faculty'. These rankings are input from our Academic constituency. (www.usnews.com/usnews/edu/college/rankings/rankengineering_brief.php) and reflect an opinion of our peer institutions. These measures include academic reputation, retention of students, faculty resources, student selectivity, financial resources, alumni giving, and graduation rate. These measures are less detailed than those used in many of the other assessment tools described above, but it is satisfying that the outcomes of these reputational measures confirm that the UW-Madison chemical engineering program is one of the leading undergraduate programs in the nation.

4.A.1 Expected Level of Attainment of Program Educational Objectives

The program educational objectives describe in general terms the ideal path and impact of our alumni during their varied careers. As such, they are more aspirational than objective. Furthermore, we fully expect that different alumni in different career tracks will excel in some areas and have less visible impact in others. The measures we have of our alumni impact are largely selective for the more successful or high-profile examples, and many are self-reported. Thus, we do expect to have a steady stream of different examples of successful alumni making their impacts. We also expect that many alumni proceed in unanticipated directions and surprise us with novel accomplishments. We do not expect to have quantifiable measures of the aggregate success of our students, so this evaluation process is of necessity more anecdotal and less objective. The continuous stream of feedback we get from the assessment tools gives us a qualitative sense of the PEOs being attained. Quantitative comparisons are made in longitudinal evaluation of results of each assessment tool.

We analyze key survey responses through comparison of the alumni ratings for how much preparation students receive at the university and how important these topics are in their jobs. The results of that comparison are provided in an 'environmental' plot. Here, we calculate average ratings using the following scales:

Very prepared	2	Frequently used
Adequately prepared	1	Moderately used
Poorly prepared	0	Not used

In such a plot, ideal results are that the most frequently used topics are those with the best preparation, and the topics not used are those with the least preparation. Thus, the ideal results would be spread from the upper right corner of the plot tailing down towards the lower left corner. Any topics above this ideal 45° line are considered more important than our preparation anticipates, and any topics far below this diagonal line may be receiving undue emphasis. It is desirable that the collection of specific skills or topics are clustered in a range near the 45° line. Another useful result for program improvement is the consensus that results regarding the ranking of relative importance of the specific skills or topics, as this assists in prioritizing between different program improvement options.

4.A.2 Evaluation Process and Analysis of Program Educational Objectives

As described above, many of our assessment tools provide evidence of achievement of the objectives, and are intended to track how our graduates achieve these objectives throughout their careers. The strongest source of information directly addressing what our graduates do once they leave Madison is our Alumni Survey. This is intended to collect information about what our alumni are achieving in their first 3-5 years while the alumni are simultaneously providing feedback on the impact of what they gained while studying the undergraduate curriculum at UW. The principle assessment tool for the PEOs is the Alumni Survey. This is administered twice in each 6-year ABET cycle, and thus examination of results of the current survey in comparison with prior surveys allows determination if the satisfactory attainment levels are being sustained or what objectives or areas show signs of change. The other assessment tools collected annually or biannually are also evaluated in context of the survey results, to see if any such variations are corroborated. This input is augmented by other assessment inputs, such as alumni news, that observe career trajectories over a longer period of 15-40 years.

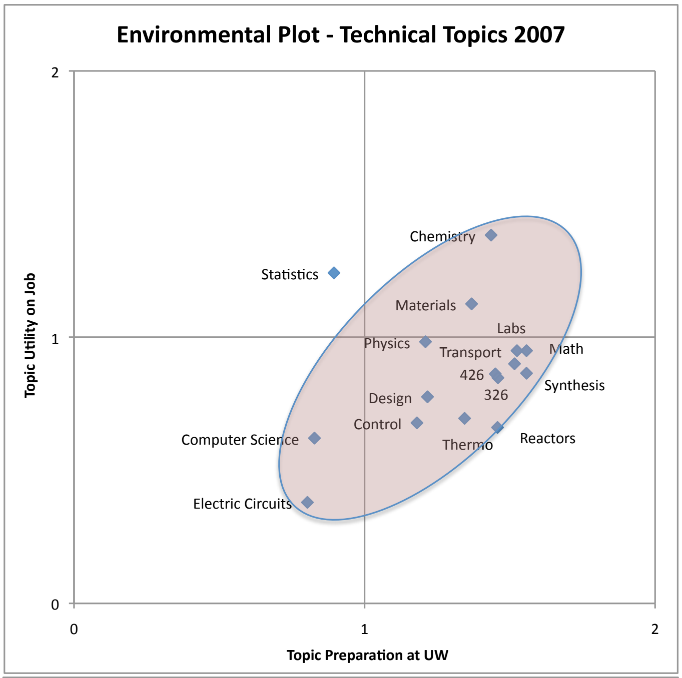
Thus, the evaluation of attainment of PEOs occurs in a cycle determined by the schedule of the Alumni Survey. A short summary of key assessment results is given below.

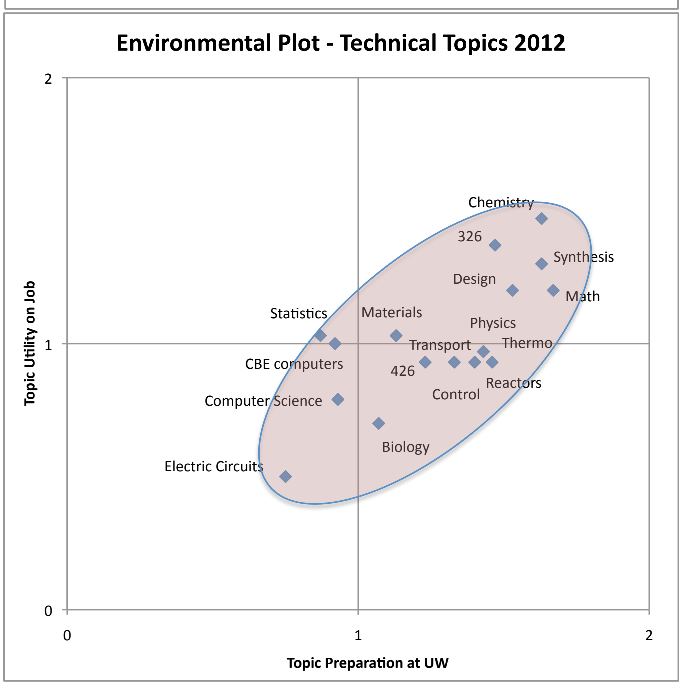
Achievement of Objective 1. *That they will exhibit strong skills in problem-solving, leadership, teamwork, and communication*

The evidence supporting demonstration of these professional skills consists of alumni survey responses. We also get less formal feedback from corporate interviewers on recent hires along with discussion of their continued interest in hiring more UW graduates. In addition, numerous comments in the alumni survey indicate that our graduates find that their performance during the first several years on the job compares very favorably with that of peers from other universities.

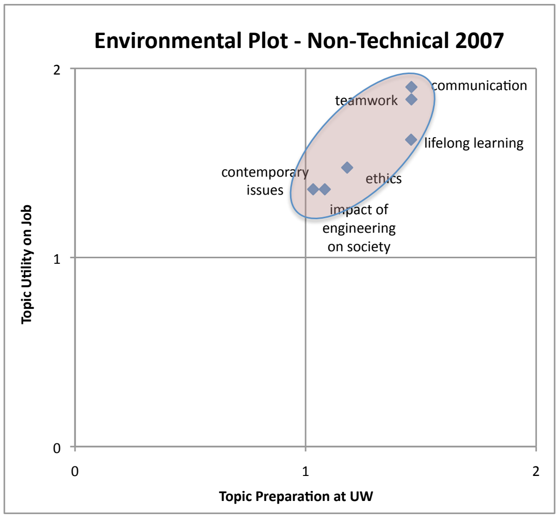
A. Alumni survey - The alumni surveys consistently indicate a very high satisfaction with the foundational aspect of their education. Plots shown in this section are from the 2007 and 2012 Alumni Surveys, and are typical of results from other years of the survey. In this 'environmental plot' format, ideal results are that the most frequently used topics are those with the best preparation, and the topics not used are those with the least preparation. Thus, the ideal results would be spread from the upper right corner of the plot tailing down towards the lower left corner. Any topics above this ideal 45° line are considered more important than our preparation anticipates, and any topics far below this diagonal line may be receiving undue emphasis.

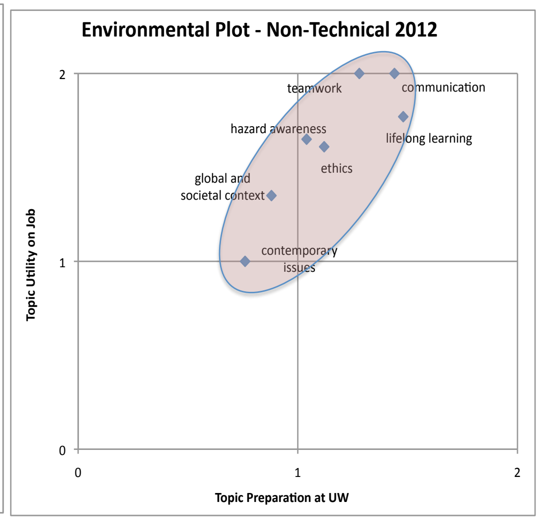
From these scores, the ‘core’ CBE topics are all perceived to be ‘over prepared’. This is interpreted as clear evidence that the curriculum preparation in these core areas is sufficiently strong for our alumni to feel no limitations in the technical aspects of their degree preparation. All of these topics are rated between adequately and very prepared. Statistics has a positive utility score and is the single area where alumni in 2007 said preparation was well below the level of use. Because of this, the 2012 Alumni Survey was expanded to ask for more detailed comments on statistics use. Improved or enhanced statistics training in several possible courses is a part of on-going and future curriculum discussions to address this aspect of preparing students to attain this aspect of Objective 1. Current activities and plans for improvements are described below in section 4.C.1.g.





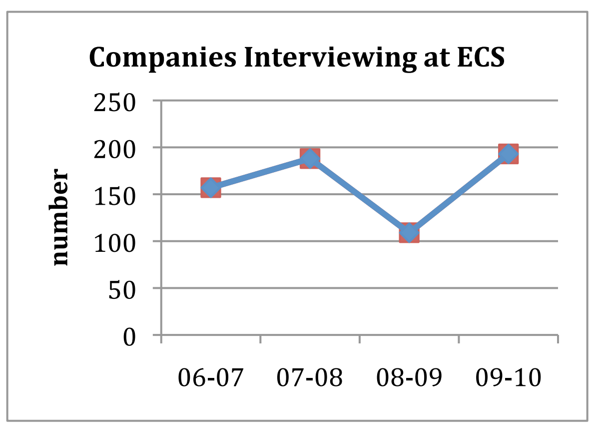
Also critical in Objective 1 are overarching non-technical skills such as communication, teamwork, and leadership. The corresponding environmental plot displaying the 2007 and 2012 Alumni Survey responses in these areas shows that the alumni recognize that these skills are even more important in their careers than the technical background they have acquired. In addition, the responses show that the alumni feel that their preparation in the program substantially prepared them to use these skills. While these responses are slightly above the 45° equity line, both preparation and job utility were reported in the upper right quadrant in 2007for a satisfactory evaluation of this assessment input. The 2012 survey also included awareness of hazards associated with processes. Ratings associated with enabling skills for Objective 1 like communication, teamwork, lifelong learning, professional and ethical responsibility, and hazard awareness continue to be strong.



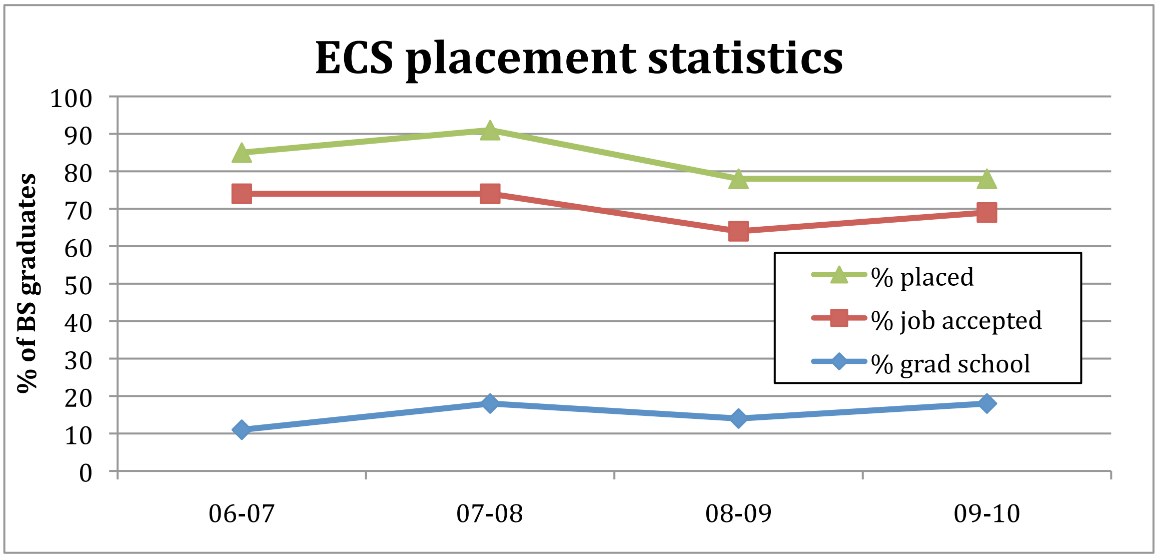


B. Visiting Committee - The departmental visiting committee reviews the undergraduate program, as well as all other aspects of the CBE program. The committee is regularly impressed by the skills of the students, and has also reviewed our assessment progress and results at some meetings. These reports will be available at the visit and also on the CBE assessment website (assessment.che.wisc.edu/).

C. Placement statistics – The strong interest of industry in employing UW graduates is an indicator of the ongoing contributions to their companies made by past UW CBE hires. Evidence of gainful employment of our students provides another measure of how well they are demonstrating strong problem-solving, leadership, teamwork, and communication skills, as the current job market demands these skills. The ECS Annual Reports contain statistics for each year on companies and students participating, number and level of salary offers reported, and percentage of students accepting an offer (employment or graduate school). Watching trends in these statistics allows us to monitor both the employment market and how our graduates are received by industry.



The number of companies interviewing CBE students on campus is a prime indicator of the performance of earlier hires from UW, and the placement success of current graduates is a blend of both the record created by earlier graduates and the particular appeal of the individual interviewing students. The number of companies interviewing CBE students through ECS shows a dip in 2008-09 when the economy slowed, but has recovered strongly since then (2010-11 data to be added when report is available). Other companies access on-line resumes through ECS even when they cannot interview on campus. Note that these company numbers are significantly increased over the 50-60 companies interviewing CBE students in the early half of the decade. Also, in the market downturn when many companies were cutting back on the number of campuses for interviews, several lead interviewers made a point of telling us that UW had been placed on their "key campus" list and saved from such cuts. In another measure of continued



strength, the ratio of companies here to recruit CBE majors to registered CBE students has varied between 2.1 and 3.8 over the same four years. The placement data also holds strong, with consistently high levels of students reporting a job accepted.

The 2009-10 report indicated that at the time it was prepared 69% of our students had accepted employment and another 18% had made commitments to pursue graduate work.

D. <u>National Rankings</u> – The UW-Madison undergraduate program has been ranked in the top five undergraduate programs in the country for many years by evaluators consisting in part of some of our key constituents, such as employers and graduate programs. The UW-Madison CBE department was most recently ranked number 6 in 2011 *US News and World Reports* listing. There is some concern that the department reputation is dropping and mixed satisfaction with being below the middle of the top 10. We are considering factors used in these rankings to see if any changes are indicated, and will monitor future rankings for future trends.

Achievement of Objective 2*. That they will use these skills to contribute to their communities*

We observe that alumni are active not only in their corporate surroundings, but also in professional and community organizations. In addition to the survey feedback, we receive a steady stream of alumni news for publication in our department newsletter that celebrates the achievements and recognition that our active alumni receive.

A. <u>Alumni survey</u> - The alumni survey indicates that at this stage of their career, most students are engaged in chemical engineering activities, such as product design, development, research, and project management. Many mention activity in professional societies, showing that they are involved in the profession beyond their particular employment and are having broader impact. In addition, alumni indicate they are involved in local government, government agencies, or even local politics.

Separately, we note that several of our alumni have participated in the Peace Corps or Teach For America; in fact, UW-Madison is recognized as one of the top campuses in the nation providing enthusiastic students for these programs. The Department has above-average participation even in this spirited group.

The 2012 Alumni Survey included a new question on professional networking, and 70% of the respondents recognized the importance of being active in a professional community.

B. Interviewer Feedback – Many of these interviewers are themselves UW CBE alumni, showing that they are active contributors to their company development and are trusted to be ambassadors and gatekeepers for recruiting the new hires critical to the future of their companies. The department and assessment chairs meet, whenever possible, with on-campus recruiters to obtain information on the career progress of graduates placed at their companies. This information is difficult to quantify since it is anecdotal in nature. We frequently hear that UW CBE is a "key school" on the recruiting lists of many major companies, but unfortunately cannot document this status systematically.

Overall, the interviewer anecdotal information is very positive, with an indication that our graduates often rise in management and are retained by the company indicating a level of satisfaction and progression in the alumni career paths.

Achievement of Objective 3. *That they will make thoughtful, well-informed career choices*

A. Alumni survey - Alumni feedback shows that the overwhelming majority of our graduates are happy with their career choices and advancement in their chosen career tracks. Many comment that their choice of a chemical engineering career positions them well for competition with their peers, and that it opens doors for a variety of tracks (management, accounting, law, medicine, etc.) that they choose to pursue. Rare cases emerge of graduates who are not enjoying their employment; however, the dominant response describes advancement in productive directions.

On a longer time scale, we also find a variety of UW graduates returning to campus as corporate interviewers and even visiting committee members. These individuals also provide anecdotal evidence that our graduates are making thoughtful decisions and being rewarded by their employers with advancement.

The alumni survey supports the satisfaction of the alumni with their preparation enabling their progression through their career paths and preparation for making informed choices.

Degree of satisfaction with preparation for career from the Alumni survey

very good	51%
good	40%
fair	2%
no response	8%

B. Visiting Committee - The departmental visiting committee indicates a high level of satisfaction of the present undergraduate students with their preparation to make thoughtful, well-informed career choices. The students have specifically commented in the most recent committee report on the coop-friendly curriculum, allowing for coop experiences without a delay in degree, as an important aspect of career preparation.

Achievement of Objective 4. *That they will demonstrate a continuing commitment to and interest in education (their own and others')*

A. Alumni survey - The self-reporting of continuing education is the primary means to assess this objective. One of the most remarkable results from the alumni survey is the number of graduates who pursue additional education. Over half of our respondents typically describe graduate study, some in chemical engineering, some towards MBAs or other business credentials, and others towards law or medical degrees.

Respondents reporting continuing education within 3-5 years

2001	2004	2007	2012
69%	79%	45%	70%

A significant fraction describes more specialized training that appears to be chosen for its particular relevance to their current job activities. These activities demonstrate that our alumni are comfortable with the reality that their undergraduate training can take them only so far, and cannot provide them all the knowledge they will need in future years, but it has prepared them for continued learning. Several of the alumni responses also mention favorably different training activities that our alumni have organized and presented to coworkers or other employees for whom they are responsible. This sharing of knowledge produces a broad impact, in addition to the slow but steady stream of our undergraduates (and graduate students) who have gone on to become university faculty and have teaching as a major priority in their career.

In the 2012 survey, 30% of the respondents reported continuing education in the form of mini-courses in a broad range of professional topics. Another 40% reported more formal education towards a professional degree.

Degree programs completed or underway in the 2012 listing were:

6	Graduate study in Chemical Engineering (5 PhD, 1 MS)
3	MBA
2	Biomedical engineering or Bioengineering
3	Law school
1	MD or DDS
1	BS Electrical Engineering

Degree programs completed or underway in the 2007 listing were:

8	Graduate study in Chemical Engineering most reported MS in ChE as well
8	MBA
3	Biomedical engineering or Bioengineering
3	Law school
3	MD or DDS
3	other doctoral programs
6	other MS programs
1	BS Biochemistry

Chemical Engineering graduate schools mentioned were Minnesota (4), MIT (3), Illinois (2), Penn State U, UC-Davis, Georgia Tech, UT-Austin, Case Western Reserve, Delaware, Penn, and UW-Madison (Biomedical).

A notable number of students are pursuing an MBA or receiving other business training rather than graduate study in chemical engineering. Business schools mentioned ranged from UW-Oshkosh to Harvard Business School.

The majority (95%) of the respondents indicated that they were very or adequately prepared in response to the question of how well the UW-Madison CBE undergraduate education prepared students in the 'ability to engage in lifelong learning and recognition of its necessity'.

Very prepared	**50.8%**
Adequately prepared	44.1%
Poorly prepared	5.1%

This appreciation of the importance of lifelong learning is part of the culture of the department, and also applies to contributing to the education of others. It is a primary objective of graduates who choose academic careers, but is also a clear professional responsibility of alumni who go into industry. Our industrial alumni often comment on training and teaching subordinates and coworkers, whether informally or as part of in-house mini-courses. We can readily document alumni dedicated to furtherance of learning in the academic sector. This culture applies to both our undergraduate and graduate programs, and they reinforce each other. Indeed, many graduate students matriculate at the department with the goal of preparing for an academic career and typically 20% of our graduate alumni follow the faculty track. Our department records show that undergraduate alumni make up 30 of the approximately 150 total alumni currently listed with faculty positions.

Undergraduate alumni in faculty positions (active):

Rajamani Gounder ('06) – Purdue University
Paul Dauenhauer ('04) – University of Massachusetts – Amherst
Andrew Spakowicz ('99) – Stanford University
Roland Kaunas ('92) – Texas A&M University (Biomedical Engineering)
James Schneider ('92) – Carnegie Mellon University
Michael Kilbey ('90) –University of Tennessee – Knoxville/ONRL

Marc Ostermeier ('90) – Johns Hopkins University
Daniel Ostrov ('90) – Santa Clara University (Math & Computer Sci.)
Michael Solomon ('90)– University of Michigan
David Suleiman ('90) – University of Puerto Rico – Mayaguez
Kendall Thompson ('90) – Purdue University
Martha Mitchell ('89) – New Mexico State University
David Mooney ('87) – Harvard University (Bioengineering)
John Weidner ('86) – University of South Carolina
Eric Shusta ('84) – UW-Madison
Anne Fuhlbrigge ('83) – Harvard Medical School
Peter Thorne ('78) – University of Iowa (Occupational and Environmental Health)
Eric Stuve ('78) – University of Washington
John Torkelson ('78) – Northwestern University
Raymond Gorte ('76) – University of Pennsylvania
John Ekerdt ('74) – University of Texas – Austin
Edward Ko ('74) – City University of Hong Kong
Jeffrey Koberstein ('74) – Columbia University
James Dumesic ('71) – UW-Madison
Harold Kung ('71) – Northwestern University
Jerry Walsh ('70) – University of North Carolina – Greensboro (Chemistry)
Dean Taylor ('65) – University of Colorado at Denver (Finance)
Dale Seborg ('64) – University of California, Santa Barbara
Gerald Kulcinski ('61) – UW-Madison (Nuclear Engineering)
John Sears ('60) – Montana State University

These responses indicate that the CBE alumni internalized the need, effectively communicated through their formal CBE experience, for continued learning and development of their skills.

Program Educational Objective Evaluation Summary

Overall, evidence indicates that the alumni are achieving the Program Educational Objectives to growing extent over the first 3-5 years after graduation, and that they continue to develop their involvement in these objectives further as they mature. Some objectives are straightforward to document, while others are more qualitative and anecdotal. Since our data collection is based on the Alumni Survey with typically 30% response rate, there seems to be little rationale for setting fixed performance levels and we continue to rely on the accumulated weight of the inputs and contacts we are able to obtain. We may add new questions to the next Alumni Survey to improve our information gathering in certain areas.

4.A.5 Documenting and Maintaining the Results

The results of the assessment and evaluation of PEOs are discussed in faculty meetings at the end of each review of a new Alumni Survey. The discussion is documented in the faculty meeting minutes. Results are also preserved in the department assessment files (paper and also web repository) so they will be available for later consultation during future reviews. With the Alumni Surveys now offered through Qualtrics survey database, as licensed by UW, this format also provides a secure site for preservation of results.

Continued improvement in coverage of the Alumni Survey will be used to further refine the feedback assessment of PEO attainment.

In 2011, the College of Engineering entered into a license agreement and pilot program with UNTRA Academic Management Systems for their AEFIS 3.0 software. The goal in implementing the AEFIS software is to streamline the data collection process to enable greater emphasis on data analysis and teaching improvement. AEFIS 3.0 is being integrated with campus databases to greatly reduce the need to enter redundant information related to both indirect and direct measures of outcomes and to collect the data into one comprehensive tool. There are four levels of implementation to the software. COE is currently working to implement the first two levels, which involve using the software as a repository for course syllabi and course evaluation results. All programs are using AEFIS to maintain current course syllabi; a few programs are using the software to house course evaluation data.

The plan is to implement AEFIS over the next four years so that it becomes a site for documenting and maintaining direct and indirect measures of Program Educational Objectives and Student Outcomes for all accredited programs. The software promises potentially an easier strategy for aligning data provided by different faculty members across the program curriculum and data gathered from outside constituents like alumni and employers. The tool will help program faculty organize, share, and store data and feedback over multiple years, thus making the ABET assessment process more sustainable.

The AEFIS system for COE is accessible at the following website: https://aefis.engr.wisc.edu/index.cfm/index.cfm. During the ABET site visit, the program can provide a username and password to enable ABET evaluators to review the current implementation of AEFIS at UW.

4.B. Student Outcomes

4.B.1 through 3 Assessment Tools, Frequency, and Expected Level of Attainment

These assessment tools were developed gradually over the last 14 years, beginning with adoption of the EC-2000 standards in preparation for the 2000 ABET visit. Several of our routinely employed measures were developed in response to the ABET-identified need to broaden the range of tools used in assessment, allowing for more varied inputs into the assessment process beyond a primary focus on grades. The specific assessment tools were identified through discussions with peer institutions and a review of practices by ABET teams within UW-Madison and other institutions (*e.g.*, Cornell, Michigan State University, Arizona State University, West Virginia State University, University of Missouri-Rolla, and others), to incorporate best practices learned from other sources. The present selection of tools was developed by a faculty subcommittee and reviewed by the entire faculty. An important factor in our choice was the utility of the information likely to be produced and the positive overlap of different tools to include the viewpoints of different constituencies in the different areas of desired information. Tools were selected to provide information on specific outcomes that identify shortcomings in our program, allowing further development and program improvement. Some tools are useful to indicate whether specific students have satisfactorily attained those outcomes. Other tools are more useful in evaluating how our constituencies assess the student outcomes and the relevance of these outcomes to their own objectives. These activities are ongoing, and the Department's documentation of our program assessment inputs and decisions based thereon has continued to grow each year. The tools used in the period 2006-2012 were selected as the most useful of the larger slate maintained before the 2006 ABET review. The "Concern" stated in a prior review was that the collection of tools and frequency of use were too large to be sustainable. The "Observation" in the 2006 review that appropriate tools were being used to good effect provided impetus to continue use of the selected primary tools with some refinements in their application. Based on the experience of the current six-year review cycle, we anticipate another evaluation of tool efficacy and utility after this review as described below in 4.C.1.f. The primary tools are:

Direct Measures

1. Co-op/Intern Employer Feedback
2. Class-based Performance Indicators

Indirect Measures

1. EBI Senior Exit Survey
2. Alumni Survey
3. Student Course Evaluations
4. Instructor Course Evaluations
5. Student Focus Groups

These primary tools derive information from the key constituents identified by the Department: alumni, undergraduates, graduating students, employers, industry, university peers and national peers. Secondary tools such as interviewer input, Visiting Committee, etc., are also useful in providing supporting evidence for issues identified elsewhere.

Direct Measures

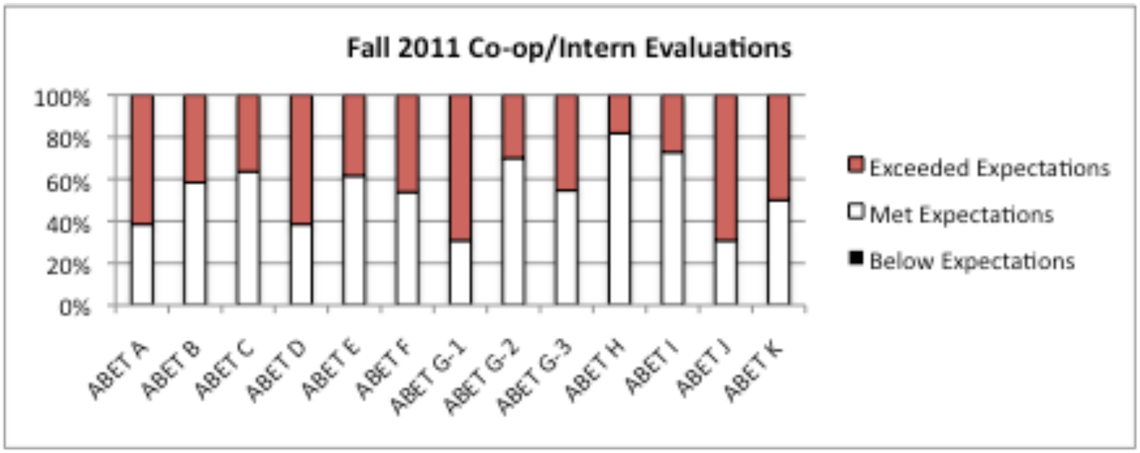
Co-op/Intern Employer Evaluations

Description: The Engineering Career Services Office of the College of Engineering collects from industrial sponsors of internship and co-op positions evaluations of the students placed with each company. *Cooperative education* is typically a semester (and often contiguous summer) spent working full-time in an engineering position at a registered company. *Internships* are summer assignments that provide student exposure to engineering jobs. Companies participating in either program register with the Engineering Career Services office and satisfy oversight requirements. The office directs specific questions to the industrial supervisor of each student to obtain feedback as to how well that student achieves or embodies the ABET objectives. Results are obtained from supervisors at the end of each semester and each summer. The industrial supervisors use a 2-page form (available at the visit) that includes the ABET a-k list. The rating scale uses statements describing student performance in each area: Exceeds Expectations (EE), Meets Expectations (ME), or Below Expectations (BE). In addition, space is provided on the survey for free-form suggestions that can prove valuable. These surveys, as well as discussions of the chair with recruiters during their visits, are used to determine current perceptions of the strengths and weaknesses of our students. As an example, the results for the Fall 2011 cohort show all students meeting or exceeding expectations (no Below Expectations scores). The balance between ME and EE scores varies from 80:20 (h – broad education necessary to understand the impact of engineering solutions in a global and societal context) to 30:70 (j – knowledge of contemporary issues).

Also note that the ECS Co-op/Intern office and company supervisors place sufficient emphasis on communication skills to split outcome (g) into three components:

g1) interpersonal skills,
g2) formal presentations, and
g3) technical writing.

This is a useful variation on the oral/written division in the EBI survey and in our Performance Indicators. As well, comments from supervisors are often useful in considering changes in curriculum content, sequence, or balance.



Documentation and Use: The co-op/Intern office collects these results every semester and each summer and forwards the results to the department. Results for each term since summer 2007 are reported here, lacking only spring 2009 when results were missed. Department files contain additional results from earlier in the 2006 ABET review cycle. The survey form used by the Co-op/Intern office is included in materials available for viewing during the visit. Copies of the individual responses (167 students over 13 recent terms) are kept in department files and are also available for inspection at the visit. These results are thus traceable to specific students, and are also useful in the aggregate to identify areas of high or low attainment of department program objectives. At a minimum, issues generated with respect to the work of an individual student are raised and addressed. Any student performing below acceptable levels in the employer's judgment is identified, and discussions with advisors and current instructors may be initiated to address these weaknesses. In the aggregate, these survey results also serve to identify areas of strength and areas of concern across the representative sample of students.

Level of Attainment and Current Assessment of Co-op Employer Evaluations: The standards applied in this assessment tool are those of the 10-20 co-op company mentors who are supervising UW students that term. Thus, their expectations are set by their corporate culture and by their experience with co-op students from other universities. This is perhaps the most objective outside input we have for directly assessing our students. However, it also introduces variability depending on which companies and which supervisors are involved each term. This variability is added to the sampling variability produced when using 10-20 students as representative of our ~300 undergraduates. It is also seen in the fluctuations in results reported in time series data at right. The overall averages from all 13 terms of evaluations (167 students) are calculated using BE=0, ME=1, and EE=2, so we see the balance is solidly between Meeting and Exceeding Expectations. Our ***desired level of attainment*** of objectives has two components: i) maintain 95+% Meeting or Exceeding Expectations (<5% BE) scores, and ii) strive for a high fraction of Exceed Expectations ratings. The table at right shows aggregate results for the 167 ratings spanning 13 terms. Seven objectives have no Below Expectations scores. Most of the BE scores are seen in Objective G – Communications, with the highest level of BE scores being 5 (3%) in objective G-1 (interpersonal communication). Formal (oral) presentations and written reports also received some BE scores but retained >30% EE scores as well. This will be discussed in context with results from other assessment tools in section *4.B.4.g - communication* below. Below Expectation ratings also tend to be clustered and student-specific, as half of the students rated BE in one outcome received a BE score in another outcome, too. Tellingly, the average overall rating is higher than any of the individual objective ratings, showing that the student performance overall is judged highly by the supervisors.

Coop/Interns	Overall averages	Total BE scores
Overall Rating	1.61	0
ABET A	1.52	0
ABET B	1.46	1
ABET C	1.34	1
ABET D	1.53	0
ABET E	1.47	0
ABET F	1.47	0
ABET G-1	1.52	5
ABET G-2	1.38	4
ABET G-3	1.33	2
ABET H	1.30	0
ABET I	1.20	2
ABET J	1.48	0
ABET K	1.40	1

Overall, the ratings are strong, with students consistently being rated as 'Meeting Expectations' or 'Exceeding Expectations'. Another useful input provided from these evaluations is the collection of comments or suggestions for curriculum improvements. These have clustered in three areas: *practical applications* of CBE fundamentals, familiarity with *statistics*, and *communication* (oral or written) skills. The application area comments invariably propose we offer elective courses to provide background for that company's industry and are impractically spread across most of the broad range of industries that employ our graduates. The attention drawn to statistics is in agreement with input from the alumni surveys. Comments from the 2012 Alumni Survey will be used discussions in summer and fall 2012 to identify a suitable scope of topics that would address statistics needs in multiple career paths. The comments on communications have reinforced similar inputs from alumni surveys and industrial inputs (i.e. recruiters and CBE Visiting Committee) support continuous effort to sustain current activities and, where possible, to increase the rigor of training in writing and add more opportunities for oral presentations. While this assessment tool samples only a subset of our students, we believe that these students are a representative sample of the core of our student body. These evaluations are thus useful as input from front-line supervisors in industry, assisting in formulating plans for curriculum revision.

Class-activity based Performance Indicators

Description: Performance Indicators are individual, graded course activities that address particular Program Outcomes. These measures provide the strongest internal documentation that our program is achieving the desired outcomes. Groups of instructors for selected courses met with the Assessment Committee to determine where the outcomes that were most significant in their course were tested, and identified an exam question, homework problem, laboratory activity, or other evaluated activity that clearly measured a specific outcome. Recognizing that these grades are normally averaged with many other activities in determining the course grade, we now record these key performance indicators separately and, at the end of the semester, report them to the Assessment Committee. Many of the activities are already assessed on a multipoint scale, while others are assessed on a "Satisfactory / Marginal / Unsatisfactory" scale or a "Pass/Fail" scale. These measures provide an aggregate measure of how well the entire class achieves the program outcome. The Assessment Committee is given the performance indicator scores for all students and compiles aggregate ratings for each measure.

Frequency of Use: This instrument was first implemented in Summer 2004. In consideration of the effort involved, most courses are sampled once a year or even every third or fourth semester. Summer Lab (CBE 424) reports results for one session each summer. The entries in Table 4.B.1 below indicate the outcomes that are monitored in particular courses. Details of which outcomes are measured, and which course activities are used to document this achievement of outcomes, are compiled in information sheets written by the core instructors for each individual course used for monitoring. These sheets are provided to new instructors, and copies of all direct measure criteria will be available for viewing at the visit.

Documentation and Use: We have developed evaluations of several courses. Specifically, since 2005 this tool has been used in CBE 250, 324, 450, 470 and the capstone laboratory course 424. It allows for the assessment by direct measures at the beginning and near the end of the students' progression through the core courses as indicated in Table 4.B.1. The collected data is available in department files and may be viewed during the visit. Discussion of this data is presented under the analysis of specific outcomes in section 4.B.4. We have recently added CBE 430 – Reactor Design as a course particularly suitable for monitoring coverage of process hazards, as well.

Level of Attainment and Current Assessment of Performance Indicators: The scores may be on any of several scales, depending on the measure and the use to be made of this measure, with corresponding base achievement targets:

Pass/Fail:		90% passing
Satisfactory/Marginal/Unsatisfactory:		90% S or M
1-5 scale:	5=excellent	
	4=good	average 3 or greater
	3=sufficient	95% 2-5
	2=marginal or minimal	track average
	1=unsatisfactory	

Table 4.B.1 Performance Indicators collected in CBE Courses

DEPARTMENTAL OUTCOMES:	CBE 250 - Process Synthesis	CBE 324 - Transport Laboratory	CBE 424 - Unit Operations Laboratory	CBE 430 - Reactor Analysis and Design	CBE 450 - Process Design	CBE 470 - Process Control		times monitored
a. 1. Ability to apply knowledge of mathematics						x		1
a. 2. science,	x							1
a. 3. and engineering						x		1
b. 1. Ability to design and conduct experiments,		x	x					2
b. 2. and to analyze and interpret data		x	x			x		3
c. Ability to design a system, component, or process to meet desired needs					x	x		2
d. Ability to functionon multi-disciplinary teams		x			x			2
e. Ability to identify, formulate, and solve engineering problems	x							1
f. Understanding of professional and ethical responsibility	x	x			x			1
g.1. Ability to communicate effectively - written		x	x		x			3
g. 2. Ability to communicate effectively - oral		x	x					2
h. Broad education necessary to understand the impact of engineering solutions in a global and societal context					x			1
i. Recognitionof the need for, and an ability to, engage in lifelong learning	x		x					2
j. Knowledge of contemporary issues					x			1
k. 1. Ability to use the techniques, skills,						x		2
k. 2. and modern engineering tools necessary for engineering practice	x	x			x	x		4
l. Working knowledge of engineering topics, including associated process hazards		x		x				2
Measurements in course	5	8	5	1	7	6		

The Performance Indicators provide strong evidence of achievement of program outcomes. The activities chosen for monitoring have uniformly shown that student performance on these key activities is satisfactory. The performance thresholds are almost always achieved; occasional missing of performance goals is examined and checked against other tools to see if this indicates a growing problem or a particular statistical outlier. However, the passing scores or distributions do show variation and are not uniformly high, so these measures also provide useful tracking information for monitoring improvements or declines in performance. The varied rating scales were chosen in 2004 to provide flexibility to instructors at the start of collecting this information from course activities. Over the intervening years of the assessment cycle the different scales have been found to be of mixed utility in describing performance and drawing conclusions. Instructors in CBE 250 and 450 have already replaced the Pass/Fail scale used for scoring several activities with the more informative Satisfactory/Marginal/ Unsatisfactory scale. We will re-examine the scales after the upcoming ABET visit to provide better guidance to assessing instructors and more useful feedback to the assessment program, as described in section 4.C.1.f of Continuous Improvement.

We shall continue to collect this Performance Indicator information for each course at least once every four semesters. The courses that collect results more frequently (as described above in "frequency of use") will be examined to determine if the student outcomes involved justify this closer monitoring or if less frequent collection of assessment results would be sufficient. Faculty will meet to refine the application of this tool to obtain the most appropriate multiple measures of student accomplishment. Individual instructors will also be encouraged to use these scores within their courses for instructional improvement.

Indirect Measures

EBI Exit Survey of Graduating Seniors

Description: This standardized Scantron survey used by the entire COE and over 60 other universities provides quantitative scores as to how well our graduating seniors perceive their curriculum has addressed generic objectives and outcomes. Questions focus on many different aspects of the ABET a-k list as well as other, non-discipline-based engineering topics. The full survey contains 72 questions, 20 of which have direct mapping to aspects of the ABET a-k student outcomes. Reports present results in several forms:

1. Absolute score average for current graduating cohort (1-7 scale, 7 is high)
2. Longitudinal comparison with previous year (we compare over longer terms)
3. Comparison with Carnegie Class peer group
4. Comparison with "Select 6" peer group, chosen by COE leaders (In 2011 this group was UT-Austin, Northwestern, U of So. Cal., Carnegie Mellon, UC-San Diego, and Columbia. Other years have included MIT, Auburn, and others.)

Documentation and Use: Quantitative scoring permits tracking of responses with time, thereby allowing us to monitor the effects of changes in curricula or individual courses. Each year we discuss the most notable high and low results from all comparisons. Since students at different universities may have different calibrations (standards?), we watch our own longitudinal comparisons most closely. A longitudinal comparison of the responses to questions most closely aligned with the Student Outcomes is shown in the table below. As a tool in annual use since 1999, this clearly provides useful data for longitudinal analysis. Complete results for all questions and comparison from each year and a summary grid with all years' scores will be available at the visit.

ABET Outcome	EBI Survey Question		99 - '10 average	10-11	change from average	change from last year
		To what degree did your engineering education enhance your ability to:				
A) an ability to apply knowledge of mathematics, science, and engineering	47	apply knowledge of mathematics	6.17	6.21	0.04	0.36
	48	apply knowledge of science	6.05	6.09	0.04	0.40
	49	apply knowledge of engineering	6.03	6.30	0.27	0.18
B) an ability to design and conduct experiments, as well as to analyze and interpret data	50	design experiments	5.32	5.55	0.23	0.55
	51	conduct experiments	5.84	5.84	0.00	0.07
	52	analyze and interpret data	6.23	6.29	0.06	0.01
C) an ability to design a system, component, or process to meet desired needs	53	design a system, component, or process to meet desired needs	5.55	5.72	0.17	0.34
D) an ability to function on multi-disciplinary teams	40	your fellow students ability to work in teams	5.63	5.66	0.03	0.31
	54	function in multidisciplinary teams	5.36	5.29	-0.07	-0.17
E) an ability to identify, formulate, and solve engineering problems	57	solve engineering problems	6.15	5.96	-0.19	-0.16
	56	Identify engineering problems	5.82	5.45	-0.37	-0.28
	55	formulate engineering problems	5.60	5.70	0.10	0.24
F) an understanding of professional and ethical responsibility	58	understand ethical responsibility	4.67	4.74	0.07	-0.26
G) an ability to communicate effectively	60	communicate using oral progress reports	5.04	5.01	-0.03	-0.11
	61	communicate using written progress reports	5.79	5.80	0.01	0.11
	70	use text materials to support project design	5.43	5.57	0.14	0.40
H) the broad education necessary to understand the impact of engineering solutions in a global and societal context	71	understand the impact of engineering solutions in a global/societal context	4.62	4.89	0.27	0.08
I) a recognition of the need for, and an ability to engage in life-long learning	62	recognize need to engage in life long learning	5.59	5.87	0.28	0.02
J) a knowledge of contemporary issues	63	understand contemporary issues	5.02	5.03	0.01	-0.05
K) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	64	use modern engineering tools	5.41	5.59	0.18	0.13
		average	5.57	5.63	0.06	0.11
		max	6.23	6.3	0.28	0.55
		min	4.62	4.74	-0.37	-0.28

Survey forms are completed by graduating seniors each semester, and the cumulative responses of each year's graduates are processed by EBI each summer. Our student participation rate is high (>85%), and we place substantial emphasis on obtaining such a high response rate. The reported response rates for our peer institutions range from 30-90%.

Level of Attainment and Current Assessment of EBI Senior Exit Survey: Each fall results and salient conclusions are presented to the department at a faculty meeting. Discussion addresses absolute scores, scores relative to Select-6 peer institutions, and longitudinal comparisons with prior years of UW student scores. Since this is a student survey we do not have absolute, arbitrary score targets. The longitudinal comparisons are watched most closely. Particular attention is paid to scores showing decreases (yellow boxes) to see if these agree with other trends. Scores showing significant increases (green boxes) are also noted. The scores on the EBI survey permit the faculty to assess the current trends in the graduating class. We consider them to have the most value as indicators of potential problem areas. Results and analyses are posted on the CBE assessment web site (http://www.che.wisc.edu/assessment/) and hard-copy files are available for the site visit.

Assessment of Results: The Assessment Committee determined that the areas of multidisciplinary teams, oral presentations, and awareness of global and societal impacts, which consistently receive the lowest scores from our students, are objects in need of constant attention. Reviews of the curriculum led to implementation of changes to improve training and provide additional experience in teamwork and oral presentations in the 2000- 2006 ABET cycle, as described in that Self Study. Discussion of continuing results in annual faculty meeting reviews emphasize the importance of sustaining the current level of activity in these areas, as well as continuing to search for opportunities for additional multi-mode communications training and for developing an increased emphasis on societal impact in particular lecture components.

Alumni Survey

Description: This instrument was first administered in 1996 to three classes of alumni (3, 5, and 15-year graduates) to obtain a broad perspective on how well the content of our curriculum prepared students for their professional activities. The general questions were initially written and analyzed by the specialists at the LEAD (Learning through Evaluation, Adaptation, and Dissemination) Center of the University. The LEAD Center (http://homepages.cae.wisc.edu/~lead/) has worked with faculty and program administrators at UW-Madison and nationwide to evaluate the impact and improve the strategies of educational programs. Their mission is to provide high-quality formative and summative evaluation for programs in education, technology, health, and social sciences. We used LEAD Center expertise to design a survey with internal checks on responses and to improve the efficiency of data analysis. In 2001, a faculty working group updated the questionnaire by adding questions to broaden coverage of the less technical program objectives, and removing extended questions on laboratory content. In addition, 'environmental' survey questions that solicited evaluation of both the level of preparation and degree of importance of chosen areas in their professional activities were inserted to aid in prioritizing areas. We focused on 3- and 5-year alumni as being more closely coupled with recent changes in the curriculum and the employment market. Since 2004, the survey was provided in paper and also using an online format that increased convenience of input for alumni and reporting for us. In 2007 and 2012 the survey was only distributed online.

Documentation and Use: The survey questions and the collected, analyzed results of each survey are stored for reference on the department assessment web site and will also be available for review in hard copy at the visit. The 2012 survey was extended with questions relating to several subjects added. The survey has been executed in 1996, 2001, 2004, 2007, and 2012. Since 2001 the survey was administered in the 1st and 4th year of each ABET evaluation cycle. In 2007 the assessment committee decided to shift this schedule to the 2nd and 5th year of each cycle to better interleave this activity with other components of the assessment program and retain the opportunity to evaluate attainment of PEOs twice each cycle. The planned 2011 survey was delayed through fall 2011 by addition of new questions relating to international experiences, undergraduate research, and other diverse opportunities. Further delay occurred when moving the survey from the earlier SurveyMonkey site to the UW-licensed Qualtrics survey system, and the survey was not released into use until spring 2012. This latest version of the survey now has responses that will be completely analyzed over summer 2012 and presented to the faculty for discussion in early fall 2012. Preliminary analysis by a survey subcommittee has found that results are generally consistent with prior survey conclusions with no large surprises. Some results are reported here along with results from earlier surveys to show typical results. Future administrations of the survey in 2014 and 2017 are planned to conform to the 2nd year and 5th year schedule.

For each implementation of the survey, the responses are compiled and a report summarizing overall results and salient comments is prepared. For the original 1996 survey, the results were analyzed by the LEAD Center personnel who prepared the survey. In subsequent surveys, we compiled the results using department staff. An executive summary that extracts conclusions and makes comparisons with the conclusions of the earlier survey is also on the assessment website. The complete response summaries for both surveys are voluminous, and are available on the website or can be provided separately if desired.

Current Assessment of Alumni Survey: The survey provides valuable inputs from alumni who have gained experience and perspective in their employment. We have shifted from the original 3, 5, and 15-year cohorts to involve just 3- and 5-year alumni in all other surveys to sharpen the focus on preparation for starting a professional position, to obtain a better link to entry-level expectations, and to better address attainment of PEOs. One concern with the survey as a tool is maintaining the quality of this input stream. The 2012 survey response rate is the lowest seen for the five surveys. The assessment committee is concerned that further decreases reflecting 'survey fatigue' may make this tool less reliable. Consultation with other survey experts may help determine if changes in the survey, the timing in the year, or the invitation/cover letter can raise the yield to desired levels. The response rate for the upcoming 2014 survey will be watched closely to see if this decline is real or is a temporary variation. This issue will also be included in discussion of updating the Assessment program as described in section 4.C.1.f below.

Alumni Survey Response Rate

1996	2001	2004	2007	2012
29%	35%	34%	43%	27%

The survey has confirmed expectations in general terms that our students feel technically prepared based on the technical background obtained during their studies at UW. Often-mentioned favorable experiences are the laboratory courses, especially the capstone Summer Lab course. The survey results have suggested that we should consider enhancements in communication skills (both oral and written presentations) and in providing supplemental skills in areas such as statistics and business-based courses. Ongoing efforts to strengthen the writing and oral presentation opportunities throughout the chemical engineering courses were also strongly motivated by the feedback from the Alumni Survey. The results of the current survey, drawing upon feedback from alumni graduating in 2007 and 2009, show influences of curriculum changes prior to those years and to new inputs.

Instructor Course Evaluation

Description: The evaluation by the course instructor complements the student evaluation forms. This form provides an opportunity for the course instructors to assess at the end of the semester 1) level of student achievement of course objectives, 2) adequacy of prerequisites and preparation, 3) level of student achievement of program outcomes, and 4) all other suggestions for future improvement. Such suggestions can include revisions to the course coverage or emphasis, refinement of course objectives, or areas for improving coordination with other courses in the curriculum. In addition to gathering input on achievement of course objectives, this form explicitly collects ratings and comments on all of the ABET a-k outcomes, information that is useful as a different perspective on student evaluations of the same list of objectives in each course.

Expected Level of Attainment for the Instructor Course Evaluation: This tool is not evaluated quantitatively. Instead, it provides a forum for instructors to note changes in student performance on any of the course objectives or even other skills used in the course. Its main purpose is for providing detailed comments useful in identifying opportunities for course or curriculum improvement.

Documentation and Use: This instrument was first implemented in Spring 2004. This form is based in part on a similar instructor course evaluation form that has been used with success by colleagues at Arizona State University. We collect these forms as a departmental resource for several purposes. At the start of each semester, the incoming instructor of each core undergraduate course may review the recent ICE forms and the conclusions concerning past changes in the course. Each spring an instructor reviews recent ICEs and reports at a faculty meeting on student performance and other issues that are important for other faculty to know. This approach has multiple purposes: it provides a record of concerns in each course to help new faculty entering the teaching rotation for that course, and it keeps the entire faculty updated on experiments and changes in presentation or content in each course to facilitate better coordination between courses in the curriculum. When course revisions are appropriate, a working group of several recent instructors in the relevant courses uses the instructor course evaluation forms as a primary source of information in planning exercises. This tool is executed online through .php scripts. All past ICE forms are stored on the web and available for current instructors to view at will. Files of ICE forms covering the period 2004-present are also collected in course-specific folders on the department server storage and will be available for review at the visit. As the AEFIS system is adopted, we may be able to use it to automate the process of collection and storage of ICE data.

Current Assessment of Instructor Course Evaluation: Most ICEs depict stable courses, with outcome attainment near expectations. One recent note relates to coverage of computer tools in CBE 255. Instructors in subsequent courses (such as CBE 430 and 470) that expect to use the increased Matlab skills are commenting on uneven mastery or retention. Data collection and discussion are underway to determine if how much this is caused by factors in presentation or timing in CBE 255, or what other changes would be helpful.

Course Evaluation Student Outcome Assessment

Description: A list of questions allowing students to assess the level of achievement of each student outcome on a 1-5 scale was added to our standard departmental Course Evaluation form in the early 2000s. These student self-assessments provide a new measure of perceived accomplishment in each of the program objectives. In addition, the survey is a much better mechanism than the department web site listing for instilling student awareness of these program objectives. The ability of students to determine their level of understanding and learning, as reported through tools such as this course evaluation form, is considered to be quite high and reliable as discussed in the recent assessment literature (for example, see Kelly Wortham and Viviana Harper in " Learning Outcomes" at http://www.aacsb.edu/knowledgeservices/LearningOutcomes.pdf).

Documentation and Use: These questions (ABET a-k and Program Outcome) are included in the standard course evaluation form used by all instructors in the Department. After completion of the semester, the instructor receives the averaged scores along with results for other questions relating to course organization, presentation, exams, homework, and other activities. The outcome scores are also extracted and compiled in a summary sheet for that semester and available online or on site for any specific or all courses. These summary sheets are evaluated each semester in the Assessment Committee review, where they can be compared with results from previous semesters and with results from other current assessment tools. In particular, these assessments of course objectives provide a quick feedback loop to show results of initiatives in the curriculum or changes in activities or emphases by individual instructors. These results vary by class makeup and instructor but longitudinal trends are considered important. They are used to identify trends and confirm concerns from other inputs. In fall semesters the course evaluation ratings are discussed within the Assessment Committee along with the EBI Senior Exit Survey results, and the committee reports for these discussions are included on the CBE assessment website. Evaluation summaries for all years since 2001 are available on the CBE assessment website and will be available on site.

Expected Level of Attainment in the Student Course Evaluations: The desired level of attainment on the 1-5 scale f is 4.0 for technical or skill objectives (a, b, c, e, k, and l), and also for (d) – teamwork and (g) - communication. The target is set at 3.5 for other non-technical objectives (f, h, i, and j) in consideration of the undergraduate student modesty or lower confidence in rating themselves in these areas. The expectation is that scores rise during progression between courses in the curriculum, and the Assessment Committee tracks the number of courses attaining target scores for each outcome. Changes in these numbers from semester to semester are regarded as more significant than absolute scores, and this is why the targets are set at a level sensitive to changes in student responses.

Current Assessment of Student Course Evaluations: This tool yields our most immediate feedback on program changes. As an input similar to the EBI Senior Exit Survey, these course evaluations ask a subset of the questions present in the EBI survey but are posed as the students' progress through the curriculum. This approach contrasts with the more thorough questioning the EBI survey imposes on the seniors upon completion of their coursework. In recent years, the students consistently rate themselves modestly on the more humanistic outcomes (professional and ethical responsibility, global and societal impact, contemporary issues), although the scores are still at or above the desired target level. (Data from both tools for each of these outcomes is presented below in individual sections.) Assessment committee reports have repeatedly identified these issues as ones that should receive increased emphasis in all classes that incorporate coverage of these matters in case studies and in examples. These scores appear to be rising somewhat, showing that students are gaining better appreciation of these issues. These evaluations also indicate that the Separations course, CBE 426, is increasingly successful in covering almost all of the outcomes. The capstone laboratory and senior design courses, CBE 424 and 450, consistently show high scores in all or nearly all outcomes as would be expected.

<u>Other Assessment Tools</u>

A variety of other tools are available and are used as needed by the department's assessment committee in its review of the curriculum and student achievements. Data from these tools are compiled and analyzed in combination with the presentation of primary tool results with full faculty review, discussion and recommendations.

Through ***focus groups*** and meetings with officers of the ***AIChE student chapter***, the undergraduates are periodically asked to assess the program. The chapter officers collect input from many of the students and present their conclusions to a small group of faculty. In past years, the students have often focused mostly on advising, quality of life issues, such as computer facilities and hours, and TA interactions. The paucity of complaints about omissions in any specific program outcome is useful information for our evaluation. This assessment measure provided by meetings with members of the student chapter complements the EBI Survey of graduating seniors. It allows students to provide more detailed responses on issues for which the EBI form has the limitations inherent in a multiple-choice format.

Data from Engineering Career Services (ECS) on ***<u>student placement</u>*** are obtained and reviewed annually. These data describe student placement statistics and employment offer levels, as well as the number and industrial sectors of the companies interviewing our students. Annually, ECS provides the Department with this information, for the graduate and undergraduate students. The data are reviewed by the chair and presented to the faculty as well as the CBE Visiting Committee and is available on site upon request. Changes in the employment opportunities for our students are discussed in faculty meetings and the CBE Visiting Committee meeting. While annual changes in the employment portfolio of the undergraduates from the Department may not be specifically meaningful, we view this input as important for long-term curricular development. For example, the increase in employment of our undergraduates by the food, pharmaceutical and biotech sectors provided secondary input to our decisions to alter the core curriculum to include courses in the biological sciences.

4.B.4 Assessment Results and Department Actions

It is important to have a clear concept of both how the outcomes are produced and how they are assessed. The entire curriculum is designed to provide the learning experience necessary for our students to achieve the student outcomes and to be prepared to accomplish the program educational objectives in their subsequent careers. The students perceive the courses as being organized to cover a broad range of engineering topics. The mapping of the different courses to the specific program outcomes is presented in Criterion 5 – Curriculum in Table 5.2.

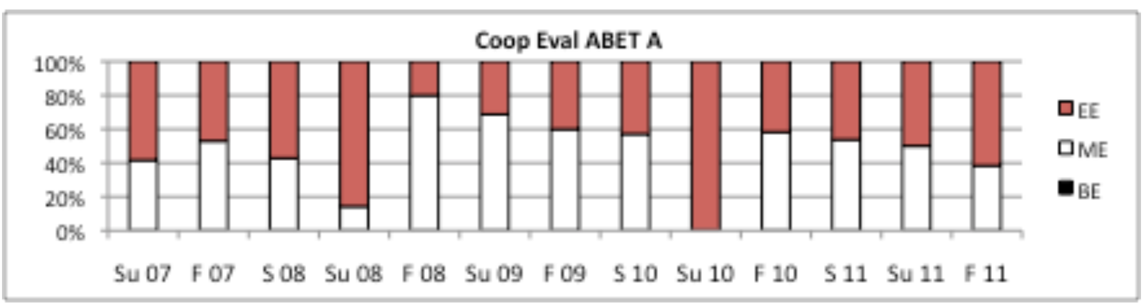
We have connected our assessment tools with individual outcomes, beyond the above structuring of courses and course content. While some of these tools can be attributed to performance of individual students, all tools allow the assessment of the program as a whole. Program outcome assessment is provided by a synthesis of many inputs, including information from instructors (graded activities and surveys), students (surveys), graduates (exit survey and alumni survey), employers (co-op and interviewer feedback), and professional peers (Visiting Committee, professional societies). Examples of the use and documentation of our primary tools were given in the previous section.

Student Outcomes:

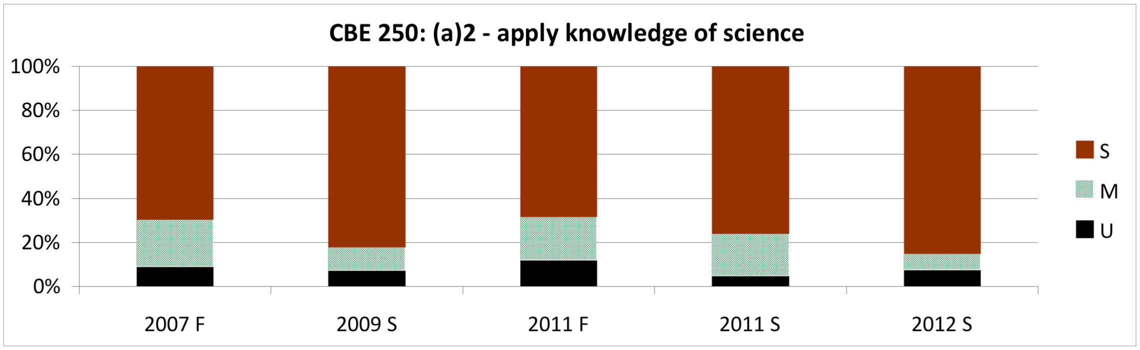
a) *an ability to apply knowledge of mathematics, science, and engineering*

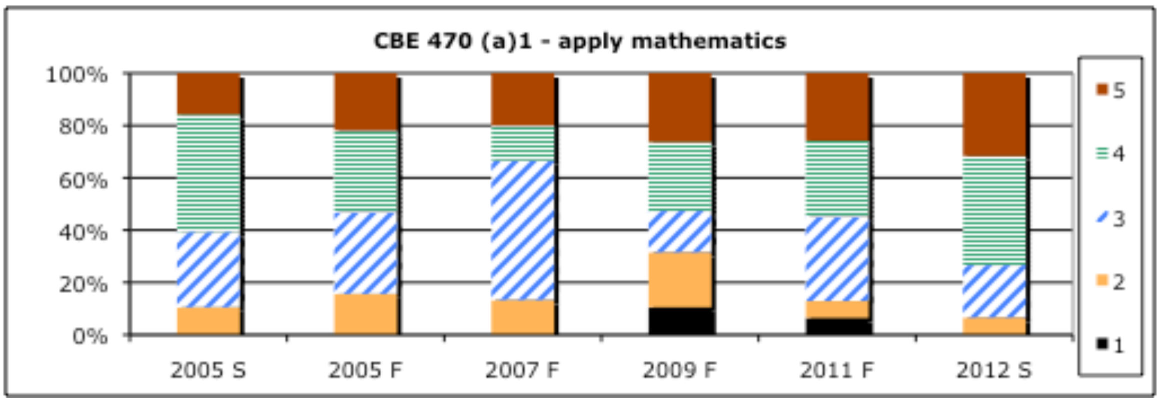
This ability is based on learning the underlying fundamentals from the early-year support courses, and is also woven into all chemical engineering courses and documented on many exams. Attainment of Outcome (a) is measured with the following tools:

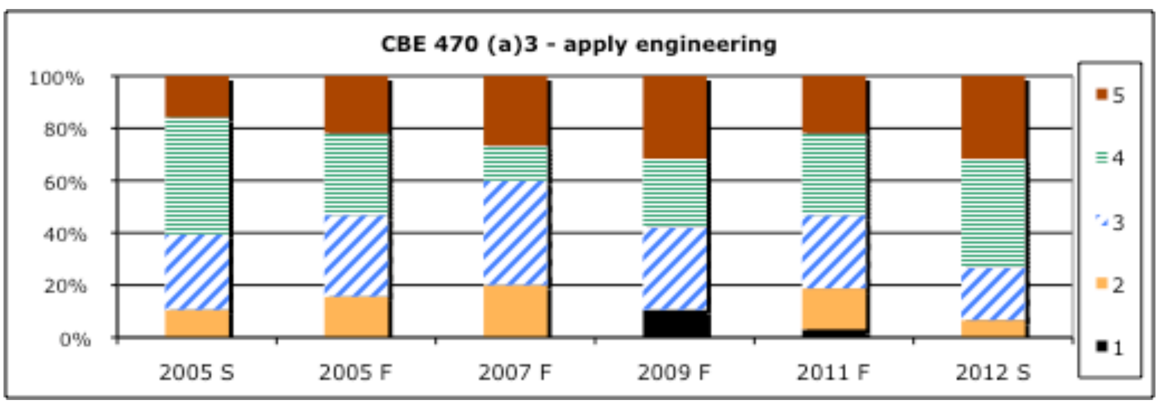
- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 250 and 470
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. Although the distribution between Meets Expectation and Exceeds Expectation varies, it averages at 48:52 for a satisfactory high performance level.

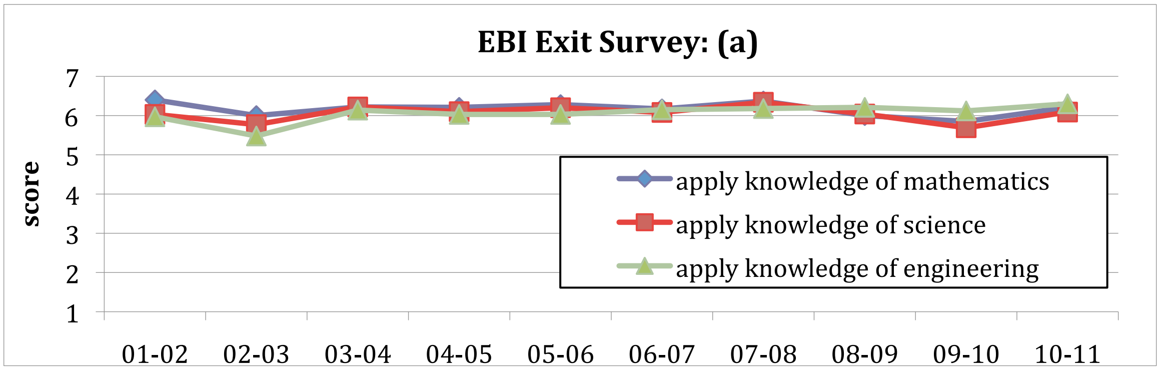






Data from Performance Indicators: CBE 250 has several homework or exam problems involving balancing chemical reactions and other basic chemistry applications that reflect student knowledge and ability. This activity recorded 91-95% Satisfactory or Marginal on the activity monitoring ability to apply science, and varied from 60 to 80% Satisfactory. The Unsatisfactory level rose to 12% only in Fall 2011 but was not repeated or reflected in other measures. CBE 470 relies heavily on Laplace transforms and other mathematics, and applies this to modeling process dynamics and determining the effects of different control strategies. Instructors use exam problem scores to assess ability in needed math and in engineering applications. For advanced mathematics this tool recorded an average of 3.6/5, with only two 'Unsatisfactory' scores (9% and 6%) in two semesters. For ability to apply knowledge of engineering, this measure averaged

3.7/5 and no 'Unsatisfactory' scores except for the Fall 2009 class that scored poorly for (a)1 as well. There were fewer scores of 'Minimal' recorded.



Data from EBI Survey: These scores are typically among the highest in the survey. The 2010-11 survey recorded scores of 6.21, 6.09, and 6.30 (1-7 scale) on the three sub-areas of this outcome. These scores are returning to our recent average.

Data from Alumni Survey: The 2007 and 2012 surveys reported that knowledge of underlying fundamentals was at or above levels needed by respondents.

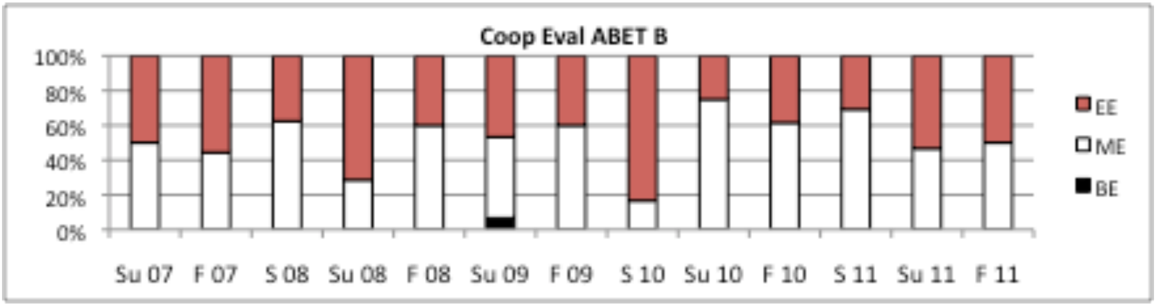
Data from Course Evaluation Outcome Assessment: Student responses consistently indicate this outcome as one of the strongest across the curriculum. In 2011, CBE 424 in the summer and 12 and 13 of the core courses during semesters returned scores at or above the target of 4.0 on the 1-5 scale.

Our students continue to meet our expectations at this outcome as given by a number of direct and indirect assessment tools. The addition of more biological content into these science areas is one of our major curricular improvements. Initial assessment, and revision to improve implementation, is described in section 4.C.1.a below. When changes are finalized, biology will be integrated into assessment of this student outcome to update the science content, and this may require another dimension of this assessment in the future.

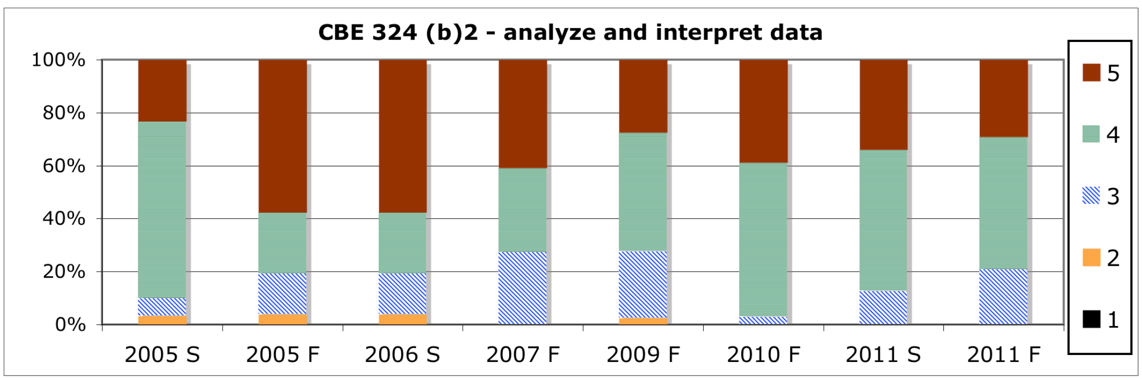
b) *an ability to design and conduct experiments, as well as to analyze and interpret data*

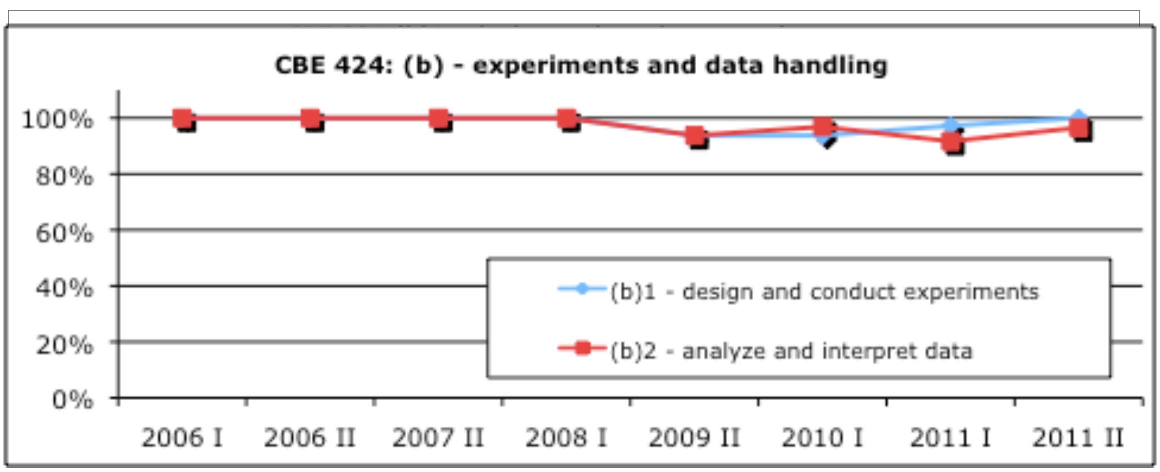
This ability is primarily developed in the chemistry and chemical engineering laboratory courses. Attainment of Outcome (b) is measured with the following tools:

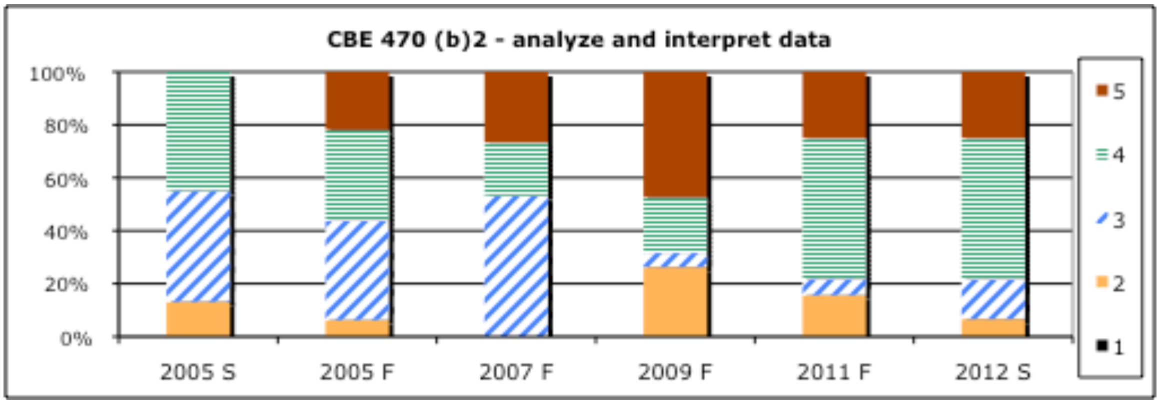
- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 324, 424, and 470
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



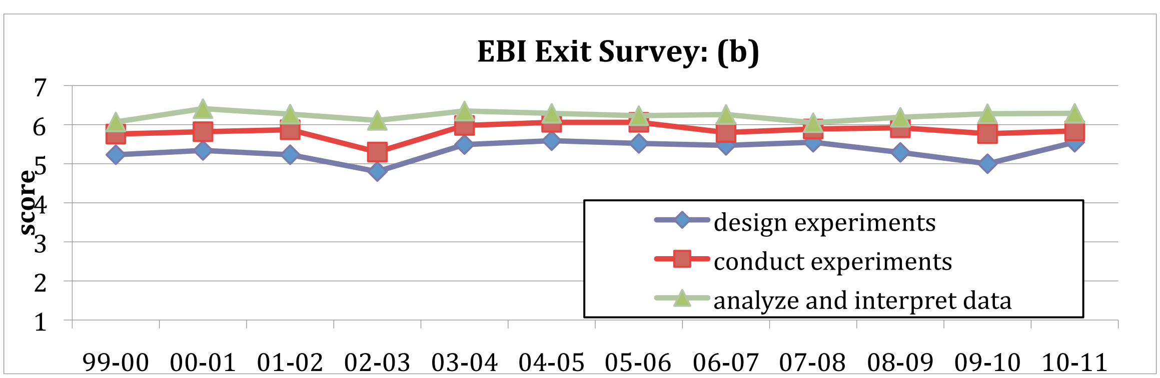
Data from Co-op/Intern Evaluations: Over 167 evaluations only one score of Below Expectation was reported (<1%). Although the distribution between Meets Expectation and Exceeds Expectation varies, it averages at 54:46 for a satisfactory high performance level.







Data from Performance Indicators: In CBE 324 Experiment A.2 – Thermal Conductivity of Solids, students select appropriate experimental conditions to collect data and extract a thermal conductivity. The grade for this experiment is used to assess designing and conducting experiments. This activity recorded an average of 4.12/5 and no 'Unsatisfactory' scores in this cycle. Experiment B.3 – Concentration Profiles in a Stagnant Film is the activity selected to evaluate student skills in analyzing and interpreting data. This activity recorded an average of 4.2/5 and no 'Unsatisfactory' scores on the activity monitoring ability to analyze and interpret data. In CBE 424 students work in pairs on four open-ended Informal experiments, where they design and assemble their own equipment to collect data addressing the assigned topics. At the end of the course the instructors assign a pass/fail score evaluating this ability. Separately, analyzing and interpreting data is evaluated based on the Distillation Formal experiment. Scores average 97% passing in both components of this outcome, with scores dropping below 95% three times of 16 scores but returning to satisfactory levels each time. CBE 470 laboratory experiments require students to analyze and interpret data. The mid-semester experiments "3 - Data Acquisition from Thermocouples" and "4 - Process Identification: Frequency Response and Step Response Modeling" have extensive analysis and interpretation. The TA uses student lab performance and the written reports to assess these abilities. Over the semesters monitored they recorded an average of 3.8/5 and no 'Unsatisfactory' scores. The semester averages ranged from 3.3 to 4.0, with the two most recent semesters posting the highest scores.



Data from EBI Survey: The 2010-11 survey recorded scores of 5.55, 5.84, and 6.29 (1-7 scale) on the three sub-areas of this outcome. The ‘design experiments’ score is recovering from a recent decline, and the ‘analyze and interpret data’ score is routinely one of our highest.

Data from Alumni Survey: The 2007 survey reported 53% of respondents rated their laboratory preparation as ‘very valuable’, and an additional 28% rated it ‘somewhat valuable’, giving a total of 81% viewing their training in experimentation as positive.

Data from Course Evaluation Outcome Assessment: Student responses consistently indicate this outcome as strongest in the courses identified with collecting and analyzing data. In 2011, CBE 424 in the summer and 4 and 3 of the lab- or data-oriented core courses during semesters returned scores at or above the target of 4.0 on the 1-5 scale.

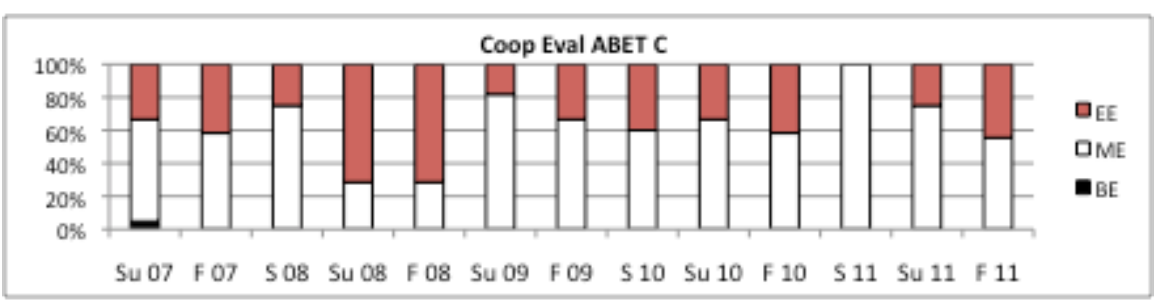
In CBE 424 –Operations and Process Laboratory (Summer Lab), students are required to conduct four open-ended assignments that follow this exact sequence after designing and constructing an appropriate experimental apparatus. Since these experiments are more than half of the course workload, passing the summer lab course is clear evidence of this ability. The alumni surveys also provide many favorable comments on the summer lab experience.

The other assessment tools indicate that our students are currently achieving this outcome at or above an acceptable level of competence.

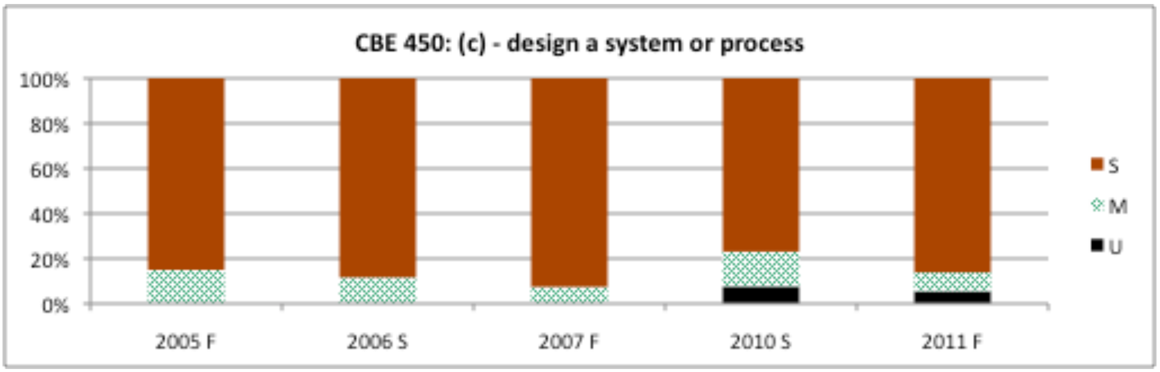
c) *an ability to design a system, component, or process to meet desired needs*

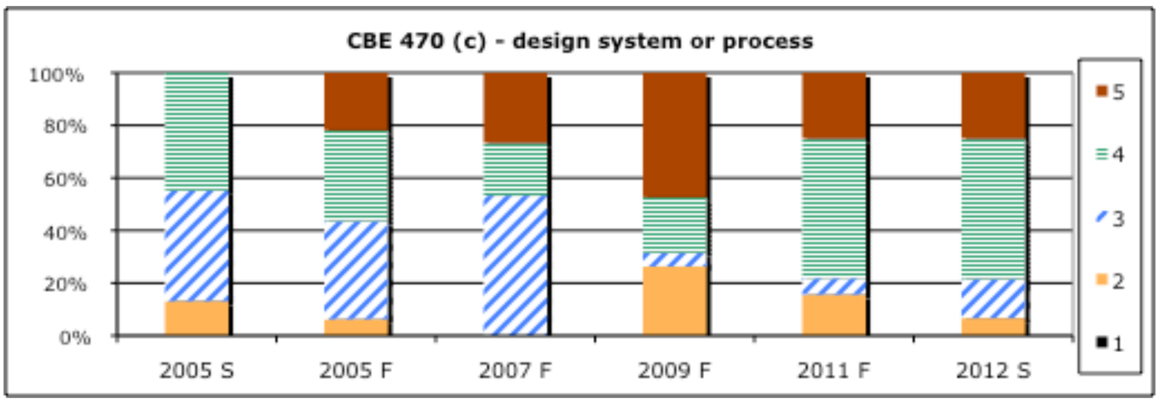
This ability is introduced in a term project in the introductory sophomore course (CBE 250), and enhanced by projects in CBE 426, 470, and other courses. In the senior (capstone) design course (CBE 450), students work in teams on a major design project that requires them to design a process to meet given specifications. Attainment of Outcome (c) is measured with the following tools:

- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 450 and 470
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations

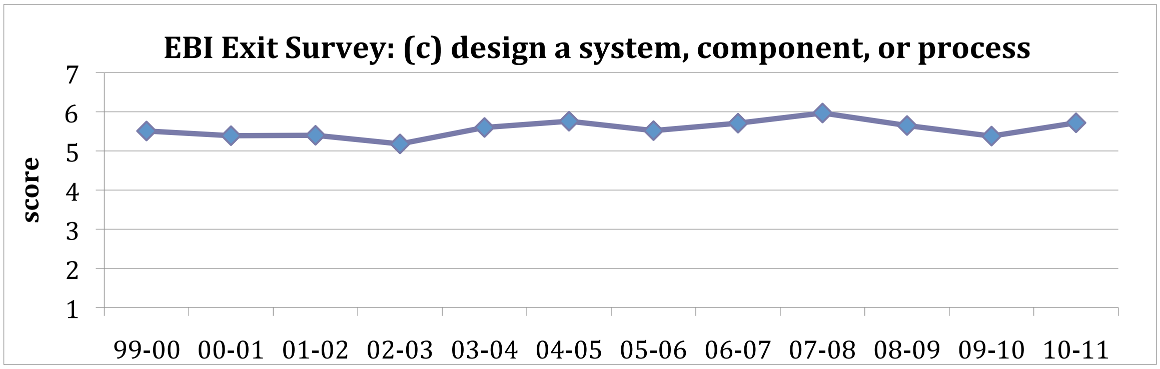


Data from Co-op/Intern Evaluations: Over 167 evaluations only one score of Below Expectation was reported. Although the distribution between Meets Expectation and Exceeds Expectation varies, it averages at 66:34 for a satisfactory high performance level.





Data from Performance Indicators: Students in CBE 450 work on both individual design projects and a major group design project. The instructor evaluates students through the class exercises and multiple progress reports and meetings leading up to a final design report and presentation. At the end of the semester the instructor evaluates each student for their demonstrated contributions to the design project. This rating averages 83% Satisfactory scores on the activity monitoring ability to design a system, component, or process. The last two semesters evaluated did show 6-7% Unsatisfactory scores. This low level is within acceptable limits but is a change from prior evaluations, so this score will be monitored to determine if it is a fluctuation or a new trend. CBE 470 uses exam questions testing student ability to design a control system for a standard unit operation for this measure. Scores over the sampled semesters showed no Unsatisfactory ratings, and recorded an average of 3.7/5 on the activity monitoring ability to design a system or process. Averages ranged from 3.3 to 4.0, with the highest scores reported in Fall 2009 and Spring 2012.



Data from EBI Survey: The 2010-11 survey recorded a score of 5.72 (1-7 scale) on this outcome. This score is above our recent average.

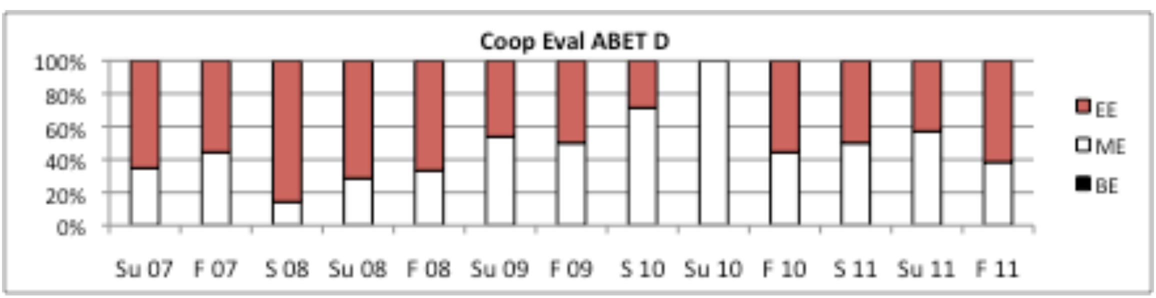
Data from Course Evaluation Outcome Assessment: Student responses indicate this outcome as strong in the courses identified with design (CBE 250, 426, 450, 470 and others). In 2011, CBE 424 in the summer and 5 and 6 of the core courses during the semesters returned scores at or above the target of 4.0 on the 1-5 scale.

The assessment tools indicate that our students are currently achieving this outcome at or above an acceptable level of competence.

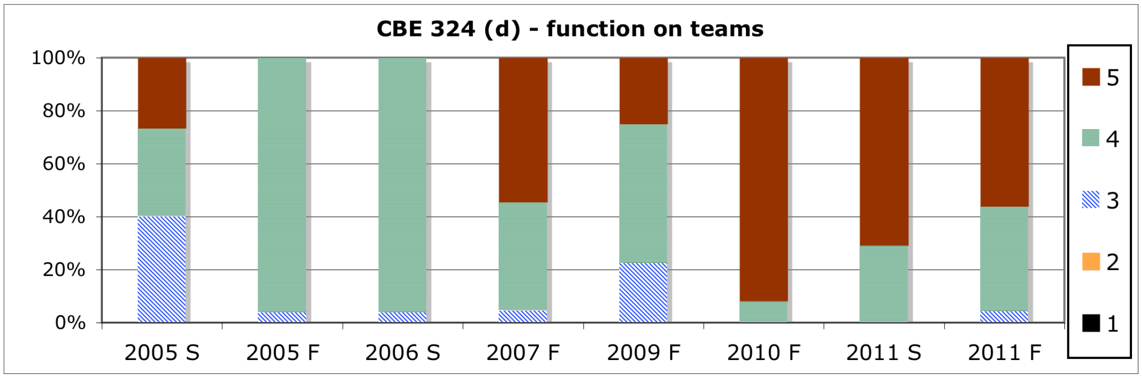
d) *an ability to function on multi-disciplinary teams*

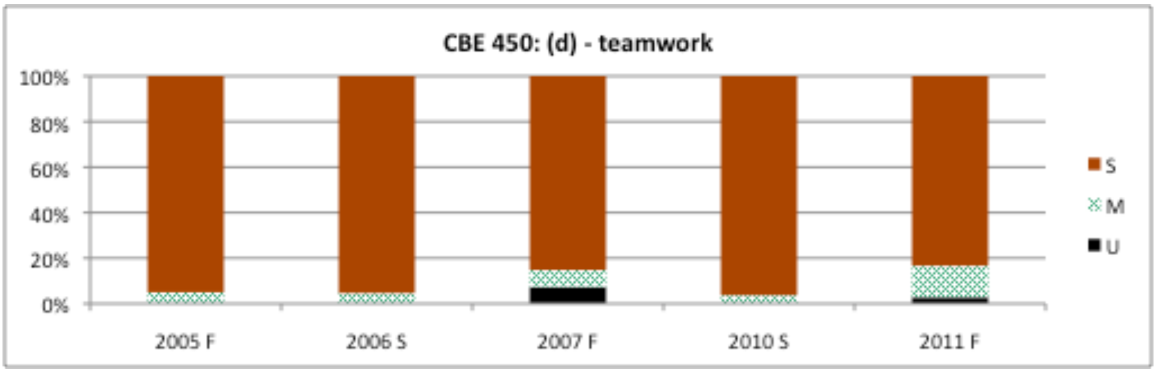
Teamwork skills are developed by frequent practice and training. Students participate in group projects in CBE 250, 324, 424, 426, 450, and 470. Attainment of Outcome (d) is measured with the following tools:

- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 250 and 470
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations

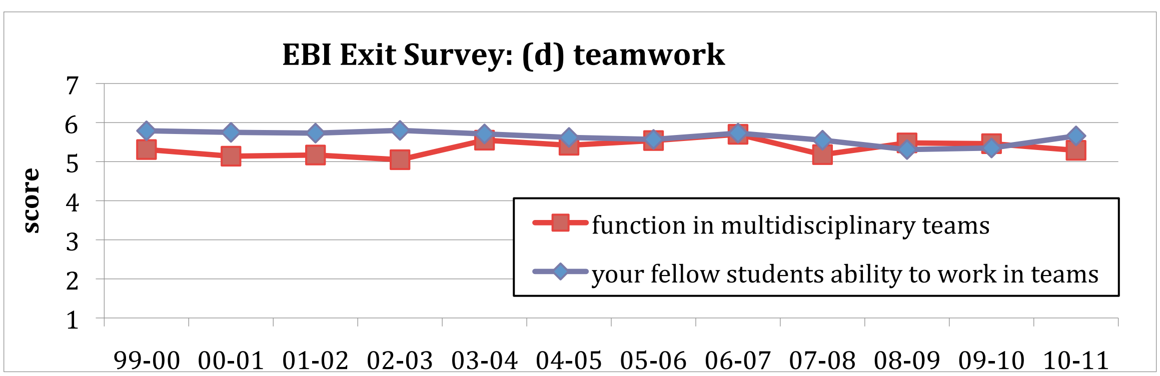


Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. The distribution between Meets Expectation and Exceeds Expectation averages at 47:53 for a satisfactory high performance level.





Data from Performance Indicators: CBE 324 uses assigned groups of 3-4 students on each experiment, and the section instructor assigns a teamwork score for each student at the end of the semester. This measure recorded an average of 4.1/5 and no 'Unsatisfactory' or 'Minimal' scores of 1 or 2 in the last cycle. CBE 450 also has students working in groups of 3-4 on their major design project, and their teamwork is evaluated by the instructor and also by self- and peer evaluations. This activity consistently records 80+% Satisfactory scores, with only low levels of Unsatisfactory scores in two of the five periods evaluated.



Data from EBI Survey: The 2010-11 survey recorded a score of 5.29 (1-7 scale) on this outcome when students rate themselves, and 5.66 on their rating of satisfaction with ability of fellow students to work on teams. These scores indicate that they hold themselves to high standards and perform well as judged by their peers.

Data from Alumni Survey: Among the nontechnical student outcomes, the environmental plot (above in section 4.A.2) shows that both job utility of teamwork and curricular preparation for teamwork get high scores second only to communication skills. In detail, the 2007 survey reported that students placed high value on teamwork skills and strongly felt that the curriculum had prepared them well for their careers. Other years had similar results.

Topic	Very prepared	Adequately prepared	Poorly prepared
Ability to function on teams	28	25	0
Percentage	53%	47%	0%

Data from Course Evaluation Outcome Assessment: Student responses consistently indicate this outcome as strong in the courses identified with team projects. In 2011, CBE 424 in the summer and 7 and 6 of the core courses during the semesters returned scores at or above the target of 4.0 on the 1-5 scale.

Feedback from Recruiters and CBE Visiting Committee: Industrial visitors constantly raise teamwork as an area of prime importance, both for their companies and for career development of new employees.

The importance of the students' ability to work on teams has been relayed to the department from a variety of our constituents. While we have gotten favorable feedback on teamwork skills from interviewers and employers, students continue to rate themselves low on this issue on self-evaluations. Employers generally choose teamwork (and communication) as areas where they ask for improved skills. We have included group projects and study groups in a broad cross-section of our courses. Students work on team projects in many courses, from their first departmental exposure in CBE 250 using in-class study groups, through project groups in upper-level courses such as CBE 426, 430, 540, and 544 culminating in the senior design (CBE 450) and capstone laboratory (CBE 424) courses. We are discussing identifying additional opportunities to have team projects.

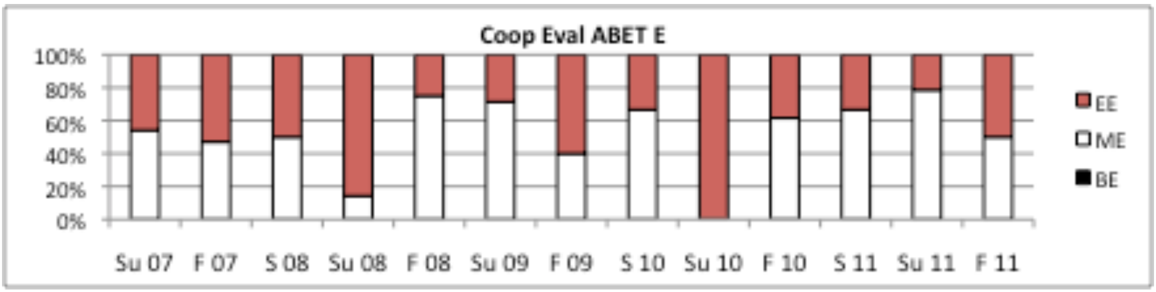
While students rate their abilities with teamwork as not strong, co-o employers and alumni rate teamwork as satisfactory or strong, and clearly are satisfied. Tellingly, the undergraduate students rate their satisfaction with teamwork skills of their classmates as higher than their own. This is another area where the lower confidence in a non-technical skill may be based partly on unfamiliarity and partly based on the comparison with their greater confidence in their well-developed technical skills .

We continue to enhance and assess our efforts at increasing the interdisciplinary, team-based skills of the students through the changes outlined above. Teamwork issues will continue to be on our 'watch list,' and we will endeavor to improve student confidence and awareness of their competency in teamwork in achievement of this outcome.

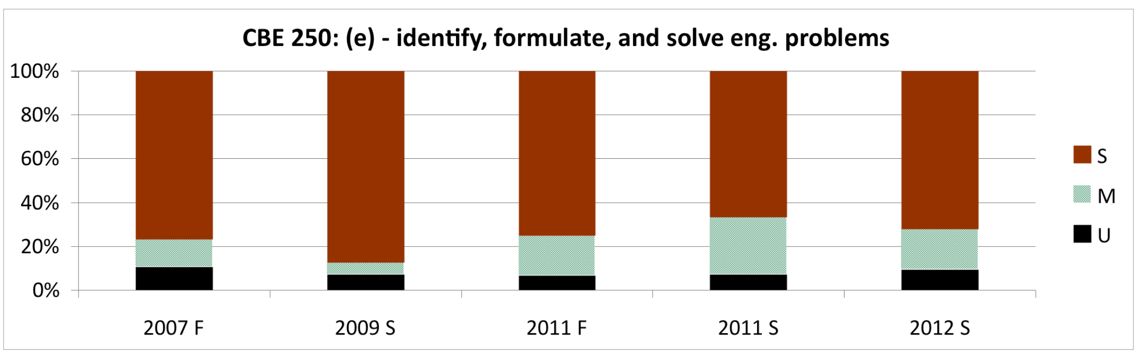
e) an ability to identify, formulate, and solve engineering problems

This ability is woven into every chemical engineering course, at constantly expanding levels. Every homework set and exam tests this outcome, and numerous final exams document this ability very well. Group projects in several courses also require students to learn and demonstrate these abilities. Attainment of Outcome (e) is measured with the following tools:

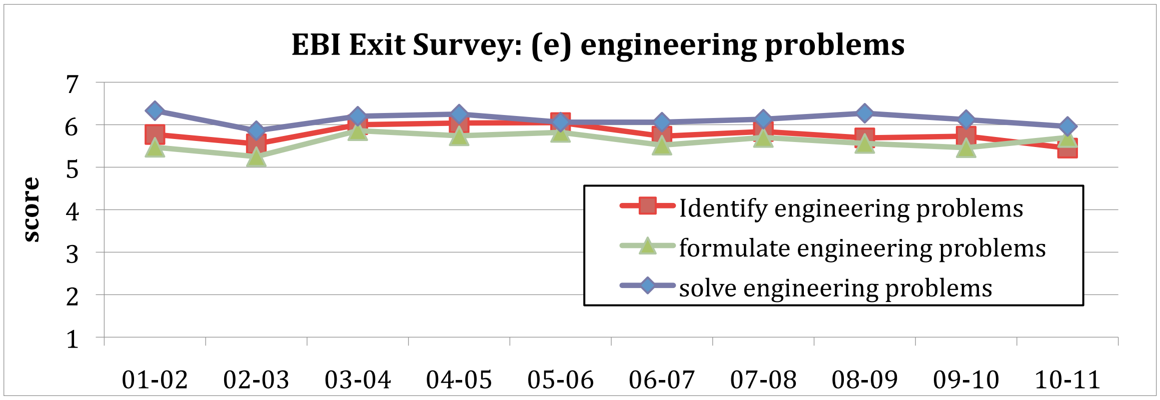
- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 250
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. The distribution between Meets Expectation and Exceeds Expectation varies, and averages at 53:47 for a satisfactory high performance level.



Data from Performance Indicators: CBE 250 uses performance on selected exam or homework problems to assess student ability to take a problem description, generate a suitable flowsheet and governing balance equations, and solve them. This activity recorded 89-93% Satisfactory and Marginal on the activity monitoring these problem-solving skills, with the low score in Fall 2007 not repeated. Satisfactory ratings of 70-80% show strong performance.



Data from EBI Survey: The 2010-11 survey recorded scores of 5.96, 5.45, and 5.70 (1-7 scale) on the three components of this outcome.

Data from Alumni Survey: In the 2007, the response to the question "How well prepared do you believe you are to compete within your field or current area of employment?" was strongly positive:

very adequate	30	57%
somewhat adequate	18	34%
somewhat inadequate	1	2%
very inadequate	0	0%
not applicable	4	8%

Many of the comments explaining their responses highlighted the strong modeling and problem-solving skills they learned in the curriculum.

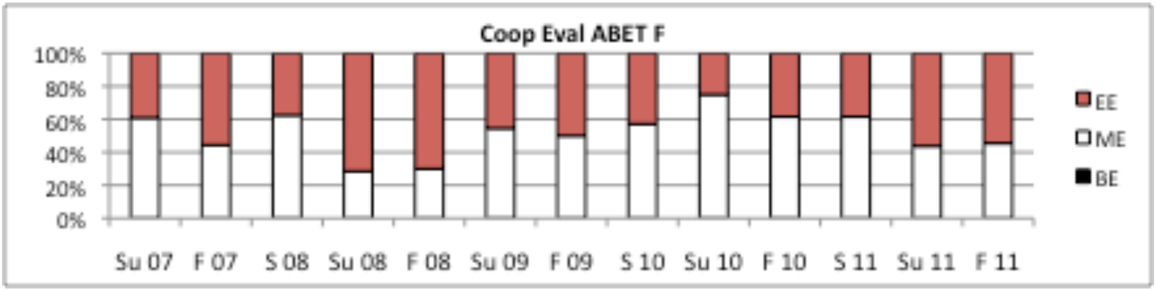
Data from Course Evaluation Outcome Assessment: Student responses consistently indicate this outcome as strong in the courses across the curriculum. In 2011, CBE 424 in the summer and 10 and 12 of the core courses during the semesters returned scores at or above the target of 4.0 on the 1-5 scale.

The assessment tools indicate that our students are currently achieving this outcome at or above an acceptable level of competence.

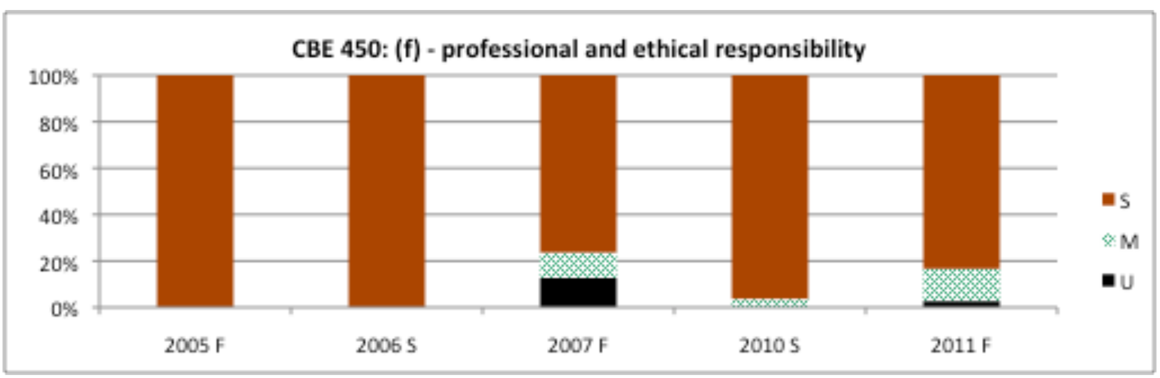
f) an understanding of professional and ethical responsibility

This issue also permeates many of the examples and applications used in most chemical engineering classes. Attainment of Outcome (f) is measured with the following tools:

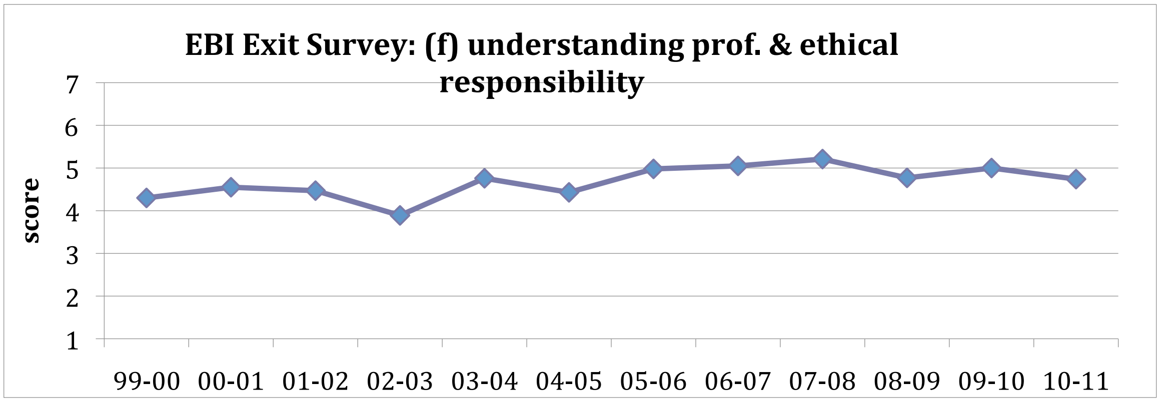
- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 324 and 450
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. The distribution between Meets Expectation and Exceeds Expectation varies, and averages at 53:47 for a satisfactory high performance level.



Data from Performance Indicators: Students in CBE 324 Transport Laboratory view the movie "Acceptable Risks" and write essay responses to several questions as preparation for an in-class discussion of a Bhopal-like accident set in California. Their scores on a question relating to viewpoints and responses from different roles (plant manager, line worker, city manager, area resident, etc.) and another relating to the AIChE Code of Ethics are used for this score. This activity has yielded an average of 4.1/5 and no 'Unsatisfactory' or 'Minimal' score. In Spring 2012 the movie and discussion questions were placed online for completion before the class meeting. Scores for the out-of-class viewing and writing rose to be predominantly 5-Excellent (the few 1-Unacceptable scores were for students not completing the activity). In CBE 450 students receive several lectures devoted to discussing professional responsibilities, and the AIChE Code of Ethics is distributed and discussed. Students complete an assignment (writing an essay or making a presentation) that discusses ethical and professional issues in practical cases, and the mark on this activity is used for this assessment. Scores through 2006 used the P/F scale, and those since 2007 use the S/M/U scale. This activity in CBE 450 recorded scores above the department targets in all periods.



Data from EBI Survey: The 2010-11 survey recorded a score of 4.74 (1-7 scale) on this outcome, which is above our average but below recent years for this item. This is one of our lower scores on the EBI Survey, and cause for further investigation into reasons for this student response.

Data from Alumni Survey: The 2007 survey reported that students on balance felt adequately prepared, but some desired additional attention to this skill.

Topic	Very prepared	Adequately prepared	Poorly prepared
Understanding of professional and ethical responsibility	14	37	2
Percentage	26%	70%	4%

Data from Course Evaluation Outcome Assessment: In 2011, CBE 424 in the summer and 12 and 10 of the core courses during the semesters returned scores at or above the target of 3.5 on the 1-5 scale.

Feedback from Recruiters and CBE Visiting Committee: Conversations with senior academic and industrial colleagues highlight this as important but hard to teach, and describe these aspects of responsibility as things they expect to see growing continuously throughout a career with accumulated experience.

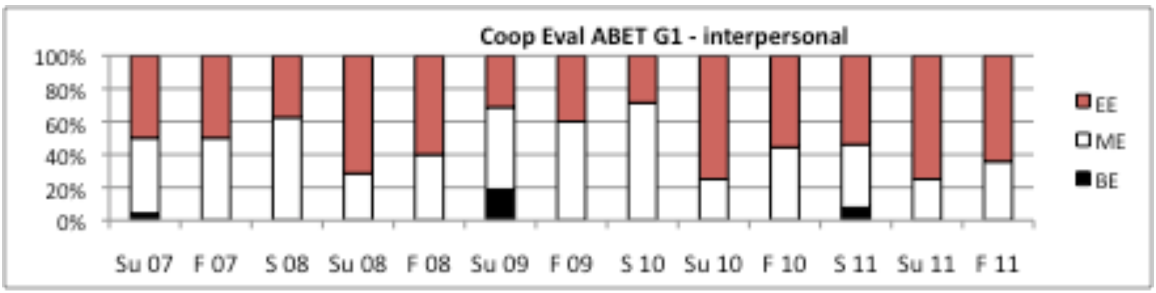
Student responses are consistently lower on this outcome. Since this skill is distributed among many courses rather than being a single module in one course, they often have trouble identifying specific examples of ethical and professional responsibility being discussed. Graduating seniors appear to be most concerned, while the recent alumni report greater confidence that their preparation in this area is adequate. Through changes in course content, we are hoping to call greater attention to these issues. We have also taught CBE 562/555 – Chemical Engineering

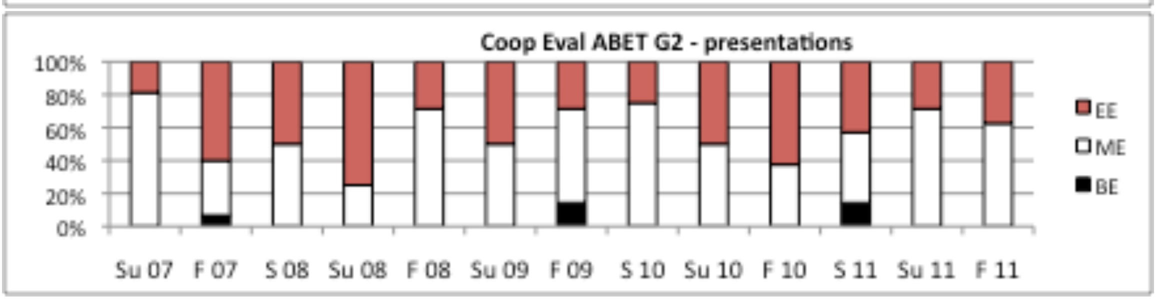
Connections Seminar for the past 7 years to provide a forum for such discussions. After evaluation, we will further determine the utility of these and other approaches.

g) *an ability to communicate effectively*

Communication skills are demonstrated in every course in the curriculum, especially in the laboratory and project courses. Attainment of Outcome (g) is measured with the following tools:

- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 324, 424, and 450
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations





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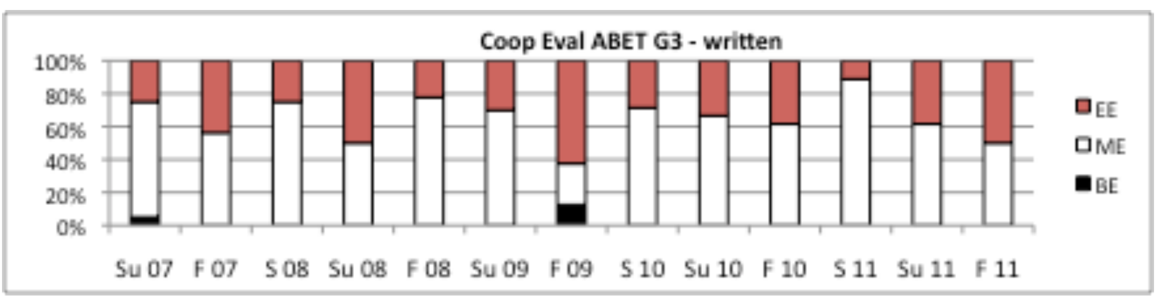
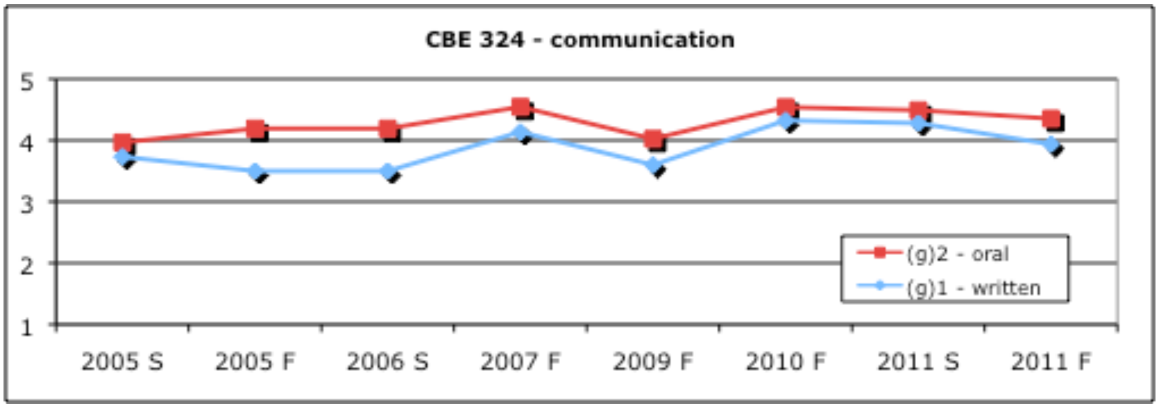
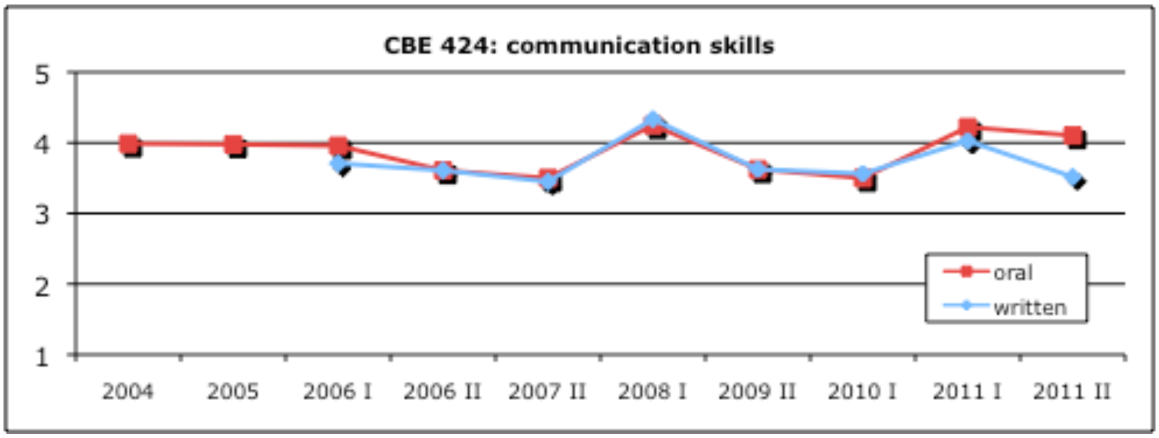
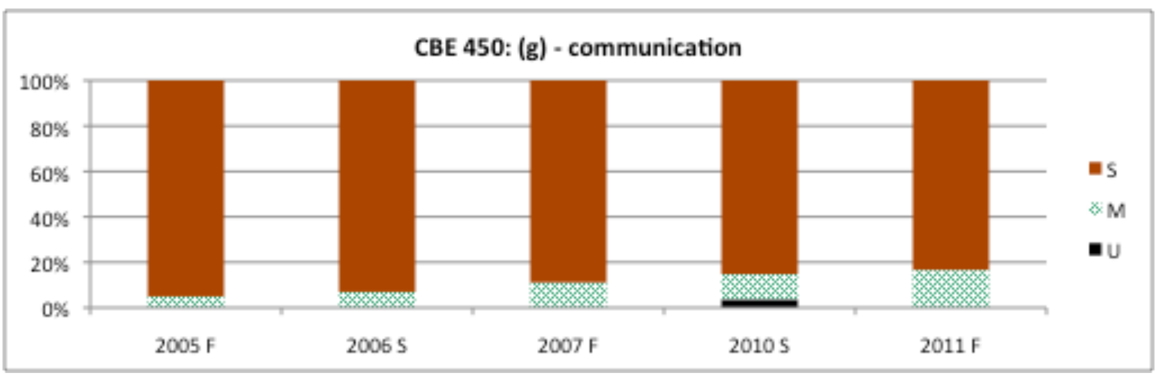


Data from Co-op/Intern Evaluations: Feedback from co-op/intern supervisors showed more concern on components of G than any other student outcome. Below Expectation scores 5, 4, and 2 in the interpersonal, oral presentation, and written components. All of these are below 4% of the 167 total evaluations and thus below the threshold, but these 11 scores of BE on communication skills dominate over the 5 scores of BE recorded for all other student outcomes. The distributions between Meets Expectation and Exceeds Expectation average at 48:52 (g1), 62:38

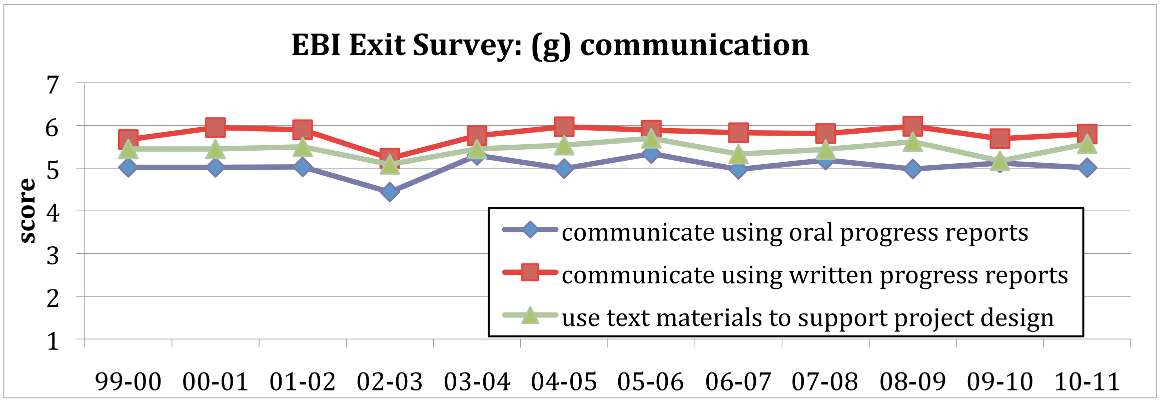
(g2), and 67:33 (g3) for a satisfactory overall performance level. The co-op supervisors are approving of report writing ability, and progressively more concerned about oral presentation skills and interpersonal meeting skills.







Data from Performance Indicators: CBE 324 develops writing skills over a series of weekly reports. Written communication is assessed at the semester end by TAs based on selected components of the last few written reports. This activity recorded an average of 3.9/5 with four 'Unsatisfactory' scores and 10 'Minimal' scores among the 8 class groups measured. The lab course also requires students to do an individual oral report on lab equipment and a group report on their open-ended experiment design. The individual oral report score is used for this performance indicator. CBE 424 recorded an average of 3.71/5 with no 'Unsatisfactory' and only 2 'Minimal' scores over the period of record for oral presentations. Scores on oral presentations in the capstone lab, CBE 424 – Operations and Process Laboratory, are higher at 4.1/5. CBE 450 also evaluates communication skills, based on the collection of a paper on ethics or green chemistry, multiple technical memos, and several group reports, and oral presentations. The individual scores on these activities are inputs into an overall rating by the instructor using the S/M/U scale. These scores in CBE 450 meet target levels.



Data from EBI Survey: The 2011-12 survey recorded scores of 5.01, 5.80, and 5.57 (1-7 scale) on oral and written communication skills, and project writing, which is at our averages for these items. Students rate themselves lower in oral presentation skills and higher in writing skills.

Data from Alumni Survey: The 2007 survey reported that students on balance felt adequately prepared, but some desired additional attention to this skill.

Topic	Very prepared	Adequately prepared	Poorly prepared
Ability to communicate effectively	21	28	2
Percentage	41%	55%	4%

In comments following this question, many students emphasized the importance of being comfortable in oral presentations in the business world. This result is also shown in perspective in the Environmental Plot in discussion of attainment of Program Educational Objective 1 in section 4.A.2. Communication skills are ranked highest for both utility and preparation of the collection of student outcomes d, f, g, h, j, and l.

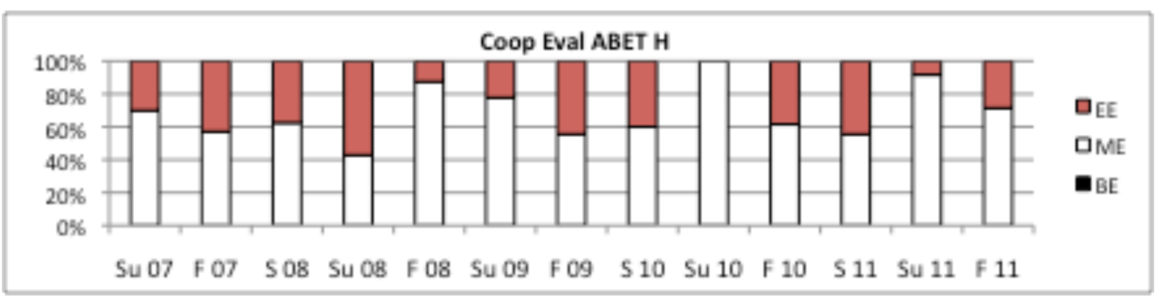
Data from Course Evaluation Outcome Assessment: In 2011, CBE 424 in the summer and 7 and 6 of the core courses during the semesters returned scores at or above the target of 4.0 on the 1-5 scale.

Course Evaluations and the EBI senior exit survey both indicate that students are confident about their writing skills; they question their own oral presentation skills but rate their classmates highly. By contrast, the instructors in CBE 324 and 424 believe that most students are better prepared to give first-rate oral presentations than they are to draft a high quality technical report. From the alumni survey and recruiter and co-op evaluation feedback, we recognize that industry places an especially high value on oral presentation skills and seeks students with yet more preparation. Both team skills and communication abilities are frequently mentioned as important areas in external assessment inputs, such as visiting committee reports and corporate interviewer feedback. These sources usually rate our students as satisfactory, but constantly encourage us to increase student experience in these areas. Increased emphasis on how students communicate in progress report meetings in CBE 424 and 450 may help improve this informal communication skill. Initiatives to increase training and practice with communications skills were a central focus of the 2000-2006 ABET cycle and were described in that Self-Study Report. The department is now sustaining those activities and the curriculum committee is alert for future areas where communication may be strengthened, but this objective is not focus of a current improvement effort.

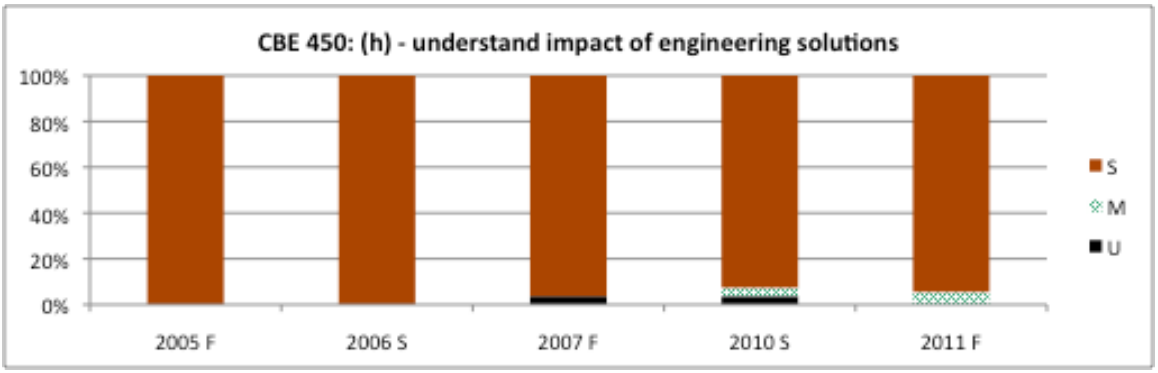
h) *the broad education necessary to understand the impact of engineering solutions in a global, environmental, economic, and societal context*

The broader impact of chemical engineering is discussed at some level in every chemical engineering course. Particular emphasis is provided in the “design bookends,” CBE 250 and CBE 450, which address design in the context of problem statements and consideration of a broad range of topics and impacts. This outcome is difficult to measure with exams, but has some presence in homework assignments. Attainment of Outcome (h) is measured with the following tools:

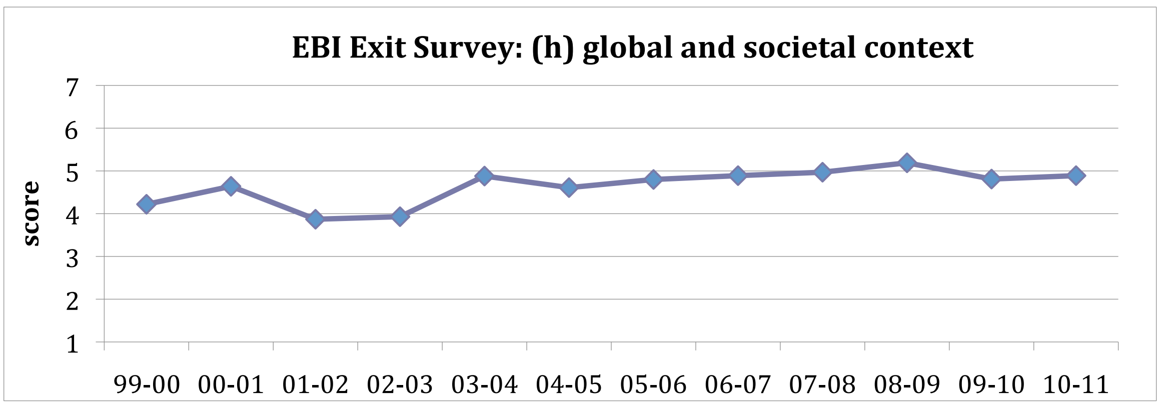
- Co-op/Intern Employer Evaluations
- Performance Indicator in CBE 450
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. The distribution between Meets Expectation and Exceeds Expectation varies, it averages at 70:30 for a satisfactory performance level.



Data from Performance Indicators: In CBE 450 students write a paper on individual projects addressing green chemistry or process accidents that give them an appreciation of environmental and societal impact of engineering projects. The score on this activity is used for this assessment. Scores through 2006 used the P/F scale, and those since 2007 use the S/M/U scale. This activity in CBE 450 recorded scores above the department targets in all periods.



Data from EBI Survey: The 2011-12 survey recorded a score of 4.89 (1-7 scale). The sustained effort across the curriculum is seen in the slow, continual rise from our start around 4.0 for this item.

Data from Alumni Survey: The 2007 survey reported that most students felt adequately prepared, but a significant fraction felt their preparation to be somewhat lacking in this skill. Other surveys show similar results.

Topic	Very prepared	Adequately prepared	Poorly prepared
Understand impact of engineering solutions in a global and societal context	4	36	12
Percentage	8%	69%	23%

Data from Course Evaluation Outcome Assessment: In 2011, CBE 424 in the summer and 14 and 10 of the core courses during the semesters returned scores at or above the target of 3.5 on the 1-5 scale. Eleven of the 26 scores above 3.5 were 4.0 or above, showing that students do have distinct awareness of this component in their coursework

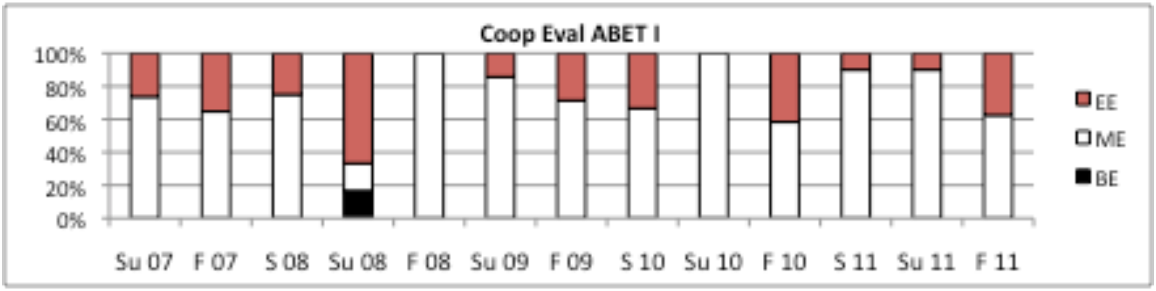
The EBI survey as well as course assessment forms have the students consistently rating themselves low in the awareness of the global and societal impact of the engineering and science content and practices. Since this topic has been frequently mentioned in our review of the EBI survey results, the faculty members have indicated an increased discussion of such impacts throughout the case studies and examples presented in all of the core CBE courses. In general, the faculty has resisted the formation of a separate course focused on this topic since they feel it would divorce the impact from the technical material that produces these impacts. The CBE department has been part of a college-wide discussion concerning the prospects for a college-wide freshman course or requirement that would explicitly address such "softer" topics in a high-visibility manner. These areas are part of an evolving discussion and by way of educating our own faculty in current practices in such freshman engineering courses, several faculty are participating in the team-taught InterEgr 102 – Grand Challenges and InterEgr 160 – Introduction to Engineering (Design) courses. Their participation will both provide some chemical engineering input to the coverage and to gain better understanding of the implementation and impact of such a freshman course. This experience will be critical in developing future plans to raise awareness among our students of what is meant by "global and societal impact."

More generally, the breadth of the educational experience of a chemical engineer is contained in the Liberal Studies requirement and the courses that it includes. Both the Department and the University have regulations regarding the distribution of these credits. In 1999, the North Central Association of Colleges and Schools renewed the UW-Madison campus accreditation and examined the standards, assessment, and strategic planning. Their report praised in glowing terms the overall undergraduate experience, and the advances in student outcomes assessment, among other factors. Since the UW-Madison is highly regarded for its liberal studies, we are confident we can rely on our colleagues across campus to maintain high standards and provide excellent liberal education courses to allow our students to understand the impact of technology in a global and societal context, no matter what liberal elective courses they choose. Another action taken to strengthen the impact of the Liberal Studies courses was the initiative in 2011 to no longer allow students to take these courses pass/fail. After the change implemented in Fall 2011, students now may use pass/fail only for free electives and not use this option for any engineering, science, or liberal studies courses. This initiative was led by Prof. Klingenberg, the CBE member of the college APCRC regulatory group.

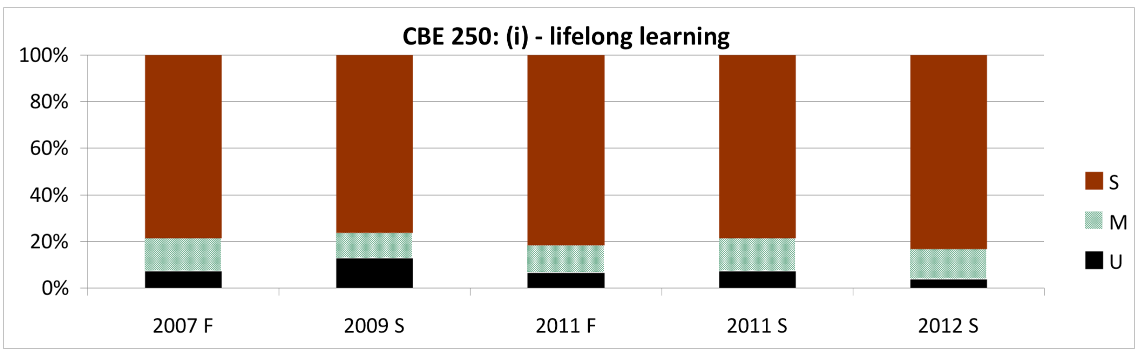
i) *a recognition of the need for, and an ability to engage in life-long learning*

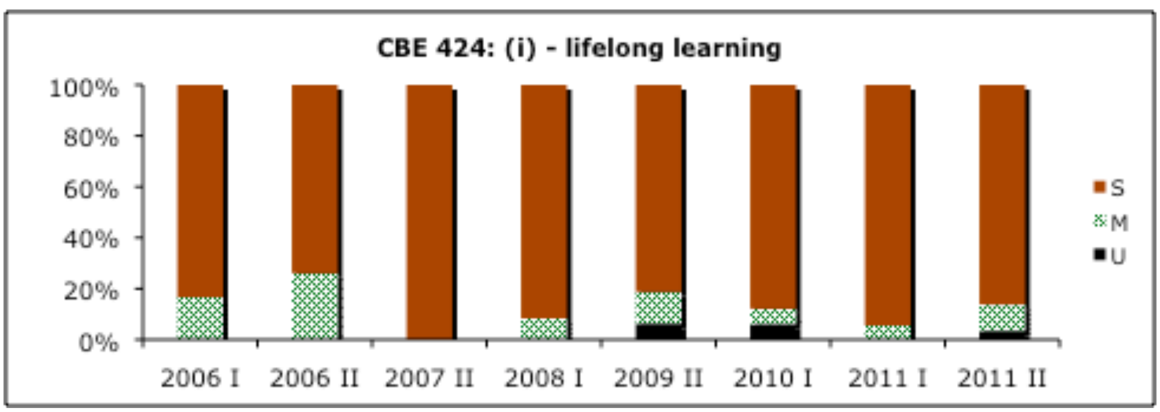
This ability is also woven into every chemical engineering course, since most courses introduce example applications with a historical treatment of innovations used to solve a problem. Attainment of Outcome (i) is measured with the following tools:

- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 250 and 424
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations

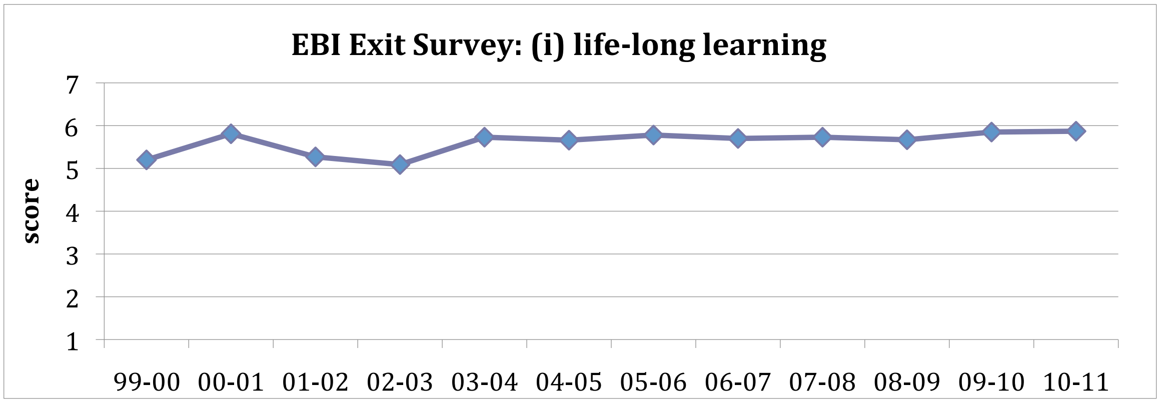


Data from Co-op/Intern Evaluations: There was one individual score of Below Expectation reported out of the 167 students evaluated (<1%). The distribution between Meets Expectation and Exceeds Expectation averaging 80% ME. Overall, this is a satisfactory performance level.





Data from Performance Indicators: CBE 250 has an early homework assignment requiring students to present a process flowsheet and notable features for a Top-50 chemical based on library research. This activity recorded scores 93-96% Satisfactory or Marginal, with only Spring 2009 dropping below the 90% target on the activity monitoring their demonstration of life-long learning skill. Satisfactory scores average near 80% for strong performance. The open-ended Informal project assignments in CBE 424 require students to use the library and other outside sources to find necessary information that is not provided in the assignment. At the end of the course several instructors for these assignments assign scores based relevant sections of the student written reports. Unsatisfactory ratings range from 0 to 5, and the Satisfactory rating ranges from 73% to 100% in different sessions. Students clearly do well with self-directed study in the lab.



Data from EBI Survey: The 2011-12 survey recorded a score of 5.5.87 (1-7 scale). This continues our strong EBI ratings in this area.

Data from Alumni Survey: The survey reported that most students felt adequately prepared. Many reported that they were already pursuing further education in their first 3-5 years out of UW; graduate study, industrial short courses, or other continuing education activities were reported by 46 of 58 respondents (79%).

Topic	Very prepared	Adequately prepared	Poorly prepared
Ability to engage in lifelong learning, and recognition of its necessity	24	27	2
Percentage	45%	51%	4%

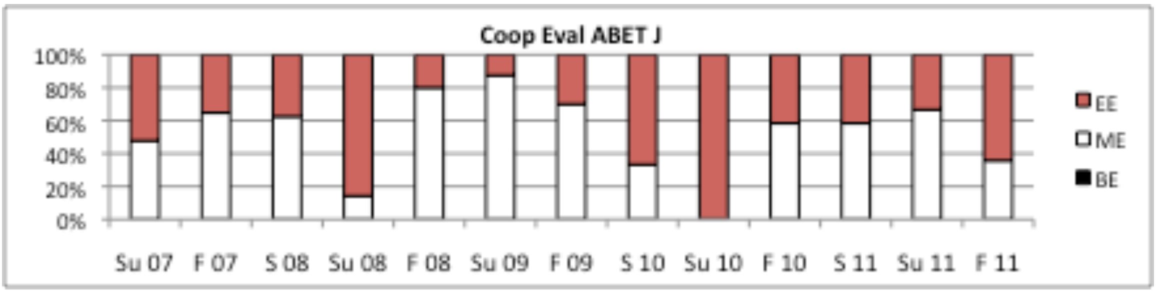
Data from Course Evaluation Outcome Assessment: In 2011, CBE in the summer and 15 and 14 of the core courses during the semesters returned scores at or above the target of 3.5 on the 1-5 scale. Although students are less confident of their abilities with this component in their coursework, 8 courses each semester did achieve the 4.0 level or above. It may be appropriate to shift the target to 4.0 in the next assessment cycle.

We continue to emphasize the changing nature of the profession and the need for adaptability through a continuing learning process. The increase of biological context is an example of such a need for continued reflection. Recognition of the rapidly changing nature of the profession is discussed frequently. At present, this aspect of our program has not been indicated as an immediate area of concern or action.

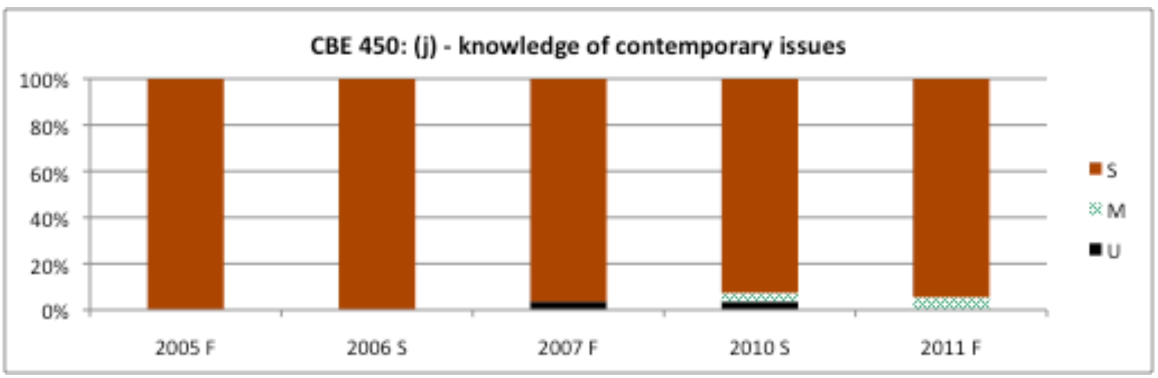
j) a knowledge of contemporary issues

Knowledge of *contemporary technical issues* is included in many courses, such as the polymers course. Knowledge of *contemporary (non-technical) issues* is enriched in the liberal electives courses, which must include humanities, social sciences, and ethnic studies courses. The department does not have direct assessment tools in use to directly measure the students' knowledge of contemporary issues gained from their liberal electives coursework, and for this relies on the indirect assessment tools such as student self-assessment as reflected in the Student Course Evaluations and the EBI Exit Survey. Attainment of Outcome (j) is measured here with the following tools:

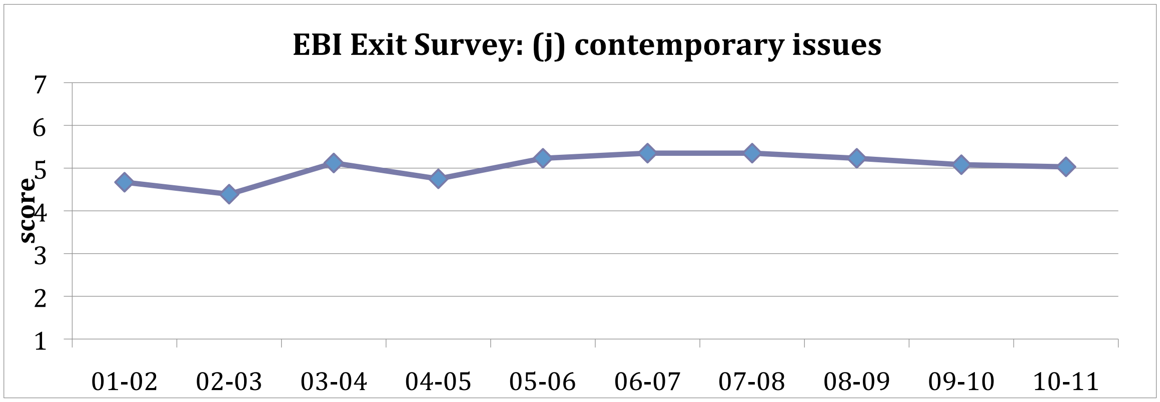
- Co-op/Intern Employer Evaluations
- Performance Indicator in CBE 450
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. The distribution between Meets Expectation and Exceeds Expectation varies, averaging at 52:48 for a satisfactory high performance level.



Data from Performance Indicators: In CBE 450 students discuss how "outside world" issues establish the background for many engineering projects, and also write a paper on individual projects addressing green chemistry or process accidents that require them to relate larger issues to engineering projects. The score on the writing activity is used for this assessment. Scores through 2006 used the P/F scale, and those since 2007 use the S/M/U scale. This activity in CBE 450 recorded scores above the department targets in all periods.



Data from EBI Survey: The 2011 survey recorded a score of 5.03 (1-7 scale), consistent with our long-term average but showing a slight decline from recent performance.

Data from Alumni Survey: The survey reported that most students felt adequately prepared, but approximately 1/3 felt their preparation to be lacking in this skill.

Topic	Very prepared	Adequately prepared	Poorly prepared
Knowledge of contemporary issues	3	34	16
Percentage	6%	64%	30%

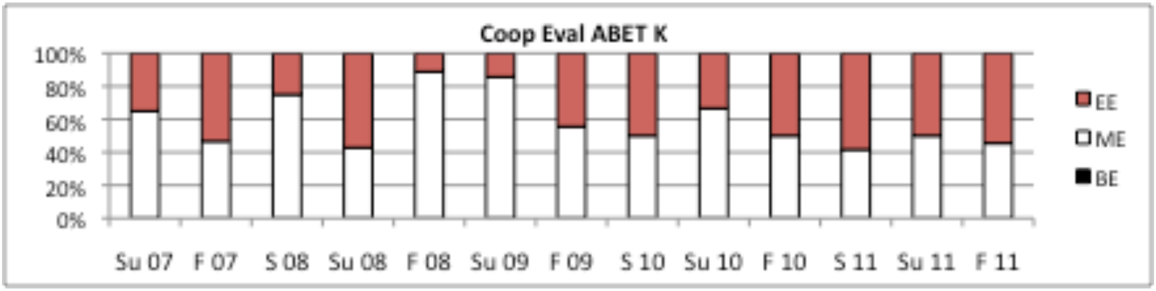
Data from Course Evaluation Outcome Assessment: In 2011, CBE 424 in the summer and 12 and 9 of the core courses returned scores at or above the target of 3.5 on the 1-5 scale. Each semester, 4 or 5 of the scores reached 4.0, also showing that students have some awareness of this component in their coursework

We are increasing the component of current issues within our course offerings principally in response to student-based indicators. Changes to CBE 250, 440, and other courses as well as the conscious effort to introduce contemporary engineering examples unobtrusively in the current courses will be monitored through course evaluations and the EBI survey.

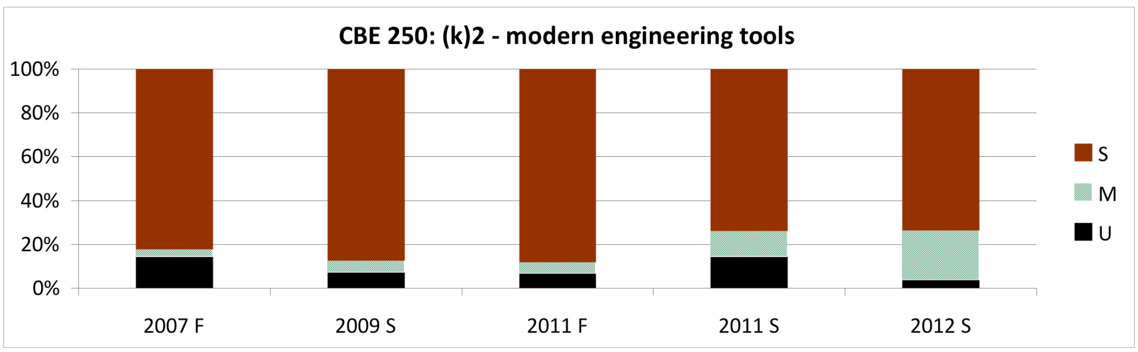
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

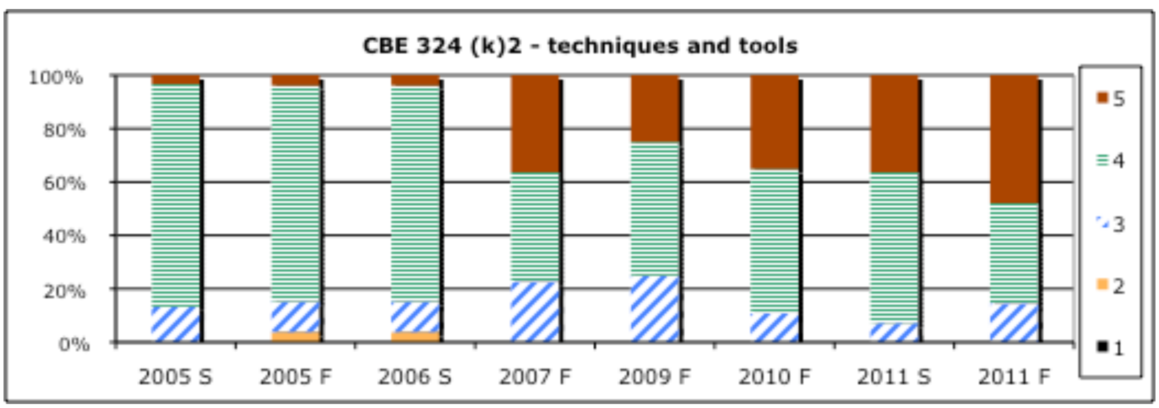
This ability is woven into every chemical engineering course, at constantly expanding levels. Attainment of Outcome (a) is measured with the following tools:

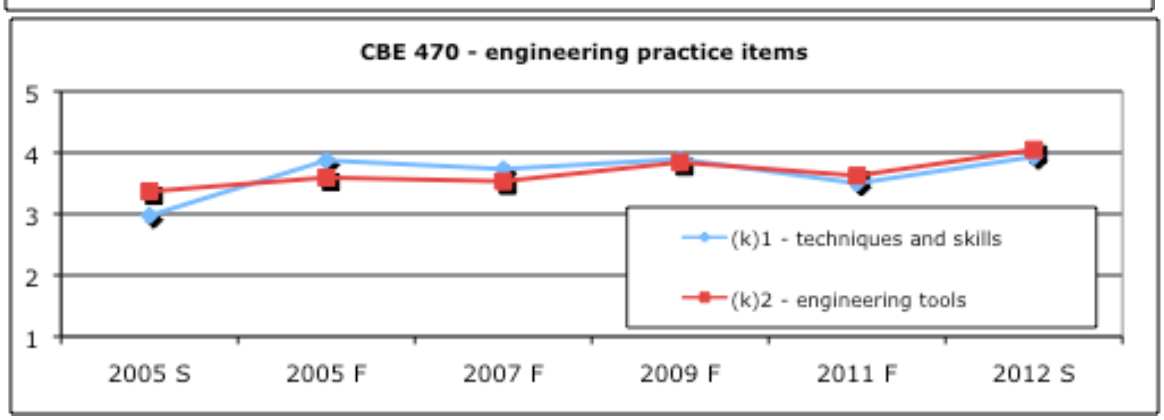
- Co-op/Intern Employer Evaluations
- Performance Indicators in CBE 250, 324, and 470
- EBI Senior Exit Survey
- Alumni Survey
- Student Course Evaluations



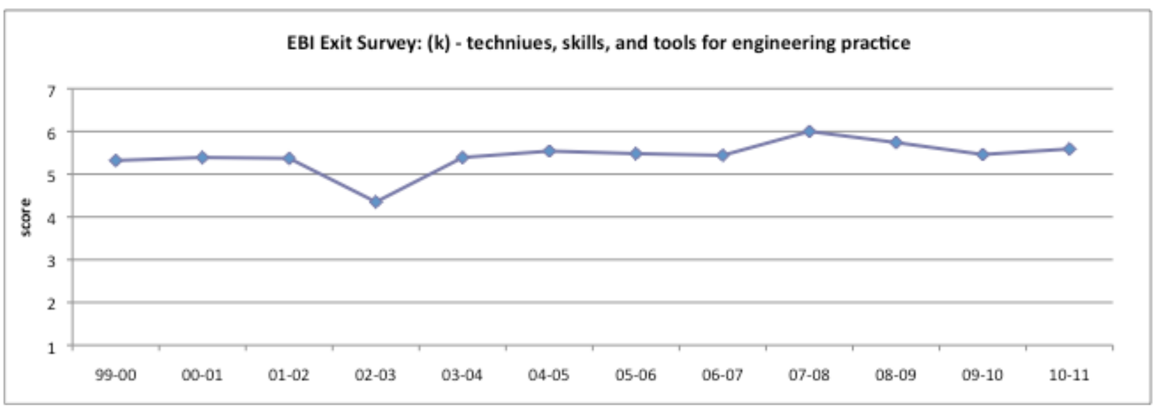
Data from Co-op/Intern Evaluations: There were no scores of Below Expectation reported. The distribution between Meets Expectation and Exceeds Expectation averages at 60:40 for a satisfactory high performance level.







Data from Performance Indicators: *1) techniques and skills:* CBE 470 laboratory work is strongly dependent on routine techniques and skill such as calibration and use of varied equipment. At semester end the lab TA provides an evaluation based on work conducted in the laboratory. Scores recorded an average of 3.7/5 over the semesters sampled, ranging from 3.4 to 4.1 in individual semesters with Spring 2012 being the highest. There were a few scores of 'Unsatisfactory' and 'Minimal' recorded. *2) modern engineering tools (esp. computer tools):* CBE 250 has several homework problems requiring use of spreadsheets for repeated calculations and generating plots showing problem solutions over a range of conditions, and numerical scores on one of these are used for this measure. This activity recorded above 90% S and M most semesters, but did drop to 86% in Fall 2007 and Spring 2011. Scores at Satisfactory varied from 75-90% for overall strong performance. CBE 324 teaching assistants observe students ability with equipment during lab experiments and assign a proficiency score at the end of the semester, recording an average of 4.1/5 with no 'Unsatisfactory' scores and two 'Marginal' score. CBE 470 experiments use LabView with associated A/D and D/A hardware interfaces. Experiments "5 – Tuning a Level Controller", "6 – Comparison of Feedback, Feedforward, and Cascade Control", and the end-of-semester course project all require the students to use these capabilities to accomplish the assignments. The lab section TA provides an evaluation of this ability based on the work conducted in the laboratory. This activity recorded scores of 3.7/5 with a range from 3.0 to 4.1. There was only one 'Unsatisfactory' score and a few scores of 'Minimal' recorded.



Data from EBI Survey: The 2011-12 survey recorded a score of 5.59 (1-7 scale), above our long-term average on this outcome.

Data from Alumni Survey: The 2012 survey reported that most students felt their technical training to be a great strength. Their overall rating of how well the UW undergraduate education prepared the responding students for their careers:

very good	16	64%
good	9	36%
fair	0	0%
no response	0	0%

Comments about skills or tools they needed tended to highlight field-specific material that was particular to their chosen industry or career track.

Data from Instructor Course Evaluations: Some evaluation forms for CBE 430 and 470 are mentioning increased use of Matlab as an ongoing improvement in their comment blocks. There is some awareness of uneven level of familiarity across the student body, and some suggestions for raising the Matlab competency of the lower students.

Data from Course Evaluation Outcome Assessment: In 2011, CBE 424 in the summer and 9 and 10 of the core courses returned scores at or above the target of 4.0 on the 1-5 scale.

The assessment tools indicate that our students are currently achieving this outcome at or above an acceptable level of competence. The slight undercurrent regarding uneven skill applying Matlab in upper-level courses is leading to a review of the presentation in CBE 255 and expected level of use in later courses, as described in section 4.C.1.b below.

l) Program criterion – ChE process knowledge, including awareness of process hazards

This ability includes most of the topics specific to chemical engineering. As seen from the grid in Table 5.B.2, components of "chemical engineering knowledge" are assessed in each of the courses in the curriculum. We do not have specific performance indicators designed to cover the range of chemical engineering process knowledge in this area, as this aspect is expected to be distributed over the entire body of chemical engineering major courses.

With the addition of "process hazards" to the Chemical Engineering Program Criterion in October of 2011, we have identified several course activities that address this topic and that are being considered as possible Performance Indicators for this subject. These involve classroom activities in CBE 324, 424, 430, and 450.

Summer Lab Informal Experiments require student pairs to design and build an apparatus suitable to conduct an experiment on each assigned topic. Appropriate hazard analysis has always been implicit. In second session 2011 students in CBE 424 were given an <u>Experiment Hazard Review Form</u> based on a BP/Amoco research lab protocol as recommended by a retired Amoco worker on our summer lab staff. Students were required to discuss their hazard review and experimental design with their Informal instructors. Forms for the 2nd Informal experiment were collected and used for assessment of student competence in this aspect. Performance was evaluated on whether the instructor rated the hazard review and safety precautions appropriate when first turned in or after one review iteration (Satisfactory), after two review iterations (Marginal), or after more than two review iterations (Unsatisfactory). The performance was acceptable.

Lab Hazard Review

S	M	U
21	8	0
72%	28%	0%

The CBE 324 Transport Laboratory already uses the "Acceptable Risks" video to initiate discussion of ethical and professional responsibility, and in Spring 2012 we added homework question addressing the planning, process hazards and accident that precipitated the disaster. The essay question was scored based on whether the student described multiple causes, a few causes, or no causes of the incident. Performance was uniformly high, with the only response at Unsatisfactory (1) for a student who did not complete the online essay question.

Video Hazard Causes				
1	2	3	4	5
1	3	8	13	26
2%	6%	16%	26%	53%

The CBE 430 unit on chemical reactor energy balances includes many examples of effects of exothermic and endothermic reactions. In Spring 2012 the instructor added explicit consideration of reactor runaway in a homework problem requiring students to view the CSB video of the T2 plant explosion and answer several questions demonstrating that they had understood the event and the recommendations of the CSB review. These were scored Pass/Fail. All answers submitted were complete and earned passing scores; the only Fail scores were received by students not completing the assignment.

T2 Explosion Lesson	
P	F
33	3
90%	10%

The CBE 450 – Process Design course also often has coverage of process hazards through activities involving choices of CSB incident reviews or green chemistry case studies, but this is not yet designed to ensure all students experience a process hazard case study. Some semesters also include coverage of Inherently Safe Design concepts. Discussions are underway between the three instructors who share course responsibility to determine what activities can be incorporated into all deliveries of this capstone design course.

We have identified several useful components for assessment of process hazard coverage and expertise, and are discussing which would be suitable for an effective assessment measure in future semesters. Action is recommended in formalizing this.

This aspect of our program has not been indicated as an immediate area of concern for student attainment.

Student Outcome Evaluation Summary

These assessment results are also applied to further develop and improve the program. Other tools such as the Instructor Course Evaluation forms may be involved less in the evaluation of attainment of the a-k outcomes but are highly valued in identifying particular aspects of courses or interactions between courses that can lead to program improvement. The faculty teaching each course grade the students based on mastery of the material or achievement of desired standards of performance. Thus, they are keenly aware of weaknesses and have the opportunity to determine whether these problems are particular to individual students, are caused by the course presentation, or originate in the curriculum that should be addressed by changes in the program. The external assessment tools provide an independent evaluation of whether our grading criteria are relevant to the larger goals. We use all these inputs to identify problems and potential solutions. A discussion of changes in our curriculum over the last six years is presented in Section 4.C. Many of these changes address improvements designed to satisfy both the program objectives and program outcomes. The process by which these changes are implemented is the responsibility of the Curriculum Committee, although in actual practice the Chair often appoints an *ad hoc* committee of the most interested faculty to bring the highest expertise to bear on each problem.

The current assessment has shown that for items a, b, c, e, i, k, and l, the CBE students are performing at or above satisfactory levels, and while we will continue to monitor these student outcomes on a regular basis, these outcomes show no need to make changes at this time. Considering outcomes d, f, g, h, and j, while our performance indicators show that faculty are generally satisfied with student performance, we do have some results from indirect measures that show students are not entirely satisfied with their education in those areas. This is useful input even if the feedback from alumni reveals that satisfaction in these areas increases after experience helps them revise their expectations with these slower-developing skills. These are important skills that we try to weave into our curriculum in strategic ways, but we will be having some faculty conversations about more effective ways to teach and monitor those student outcomes.

4.B.5 Documentation and Maintenance of Results (Student Outcomes)

The results of the assessment and evaluation of Student Outcomes are discussed in faculty meetings each semester when results of new assessment tools are received. Early each fall the EBI Senior Exit Survey results are presented along with highlights of ongoing assessment tools. Each spring a discussion is centered on review of Instructor Course Evaluation feedback along with highlights of ongoing assessment tools. Less frequent activities such as Visiting Committee input and Alumni Surveys are discussed as they occur. The Faculty Meeting Minutes summarize the content and conclusions of the discussions, and provide a permanent record of these activities.

The assessment tool raw results obtained each semester are preserved by the Assessment Committee in department files or online in a dedicated file server, and reports and faculty meeting presentations are posted on the department assessment web site. Thus, they are available for later reference by any interested faculty or visitor in case questions arise in later semesters that require additional analysis not included in the original faculty meeting discussion.

Section 4.A.5 provides details about a new software program, AEFIS, that the COE is in the process of implementing for documenting and maintaining data from student outcome assessment. While the College is currently in the early stages of AEFIS implementation, the plan is to reach full implementation over the next four years. The tool will help program faculty organize, share, and store data and feedback over multiple years, thus making the ABET assessment process more sustainable.

4.C Continuous Improvements

Improvements to the program occur both as determined by the chemical engineering program and by larger working groups acting across the college. Most specific improvements are implemented directly by the department through the assessment and evaluation procedure described above. College initiatives span multiple programs and have college-wide aspects that impact many departments. The sections below describe activity on both scales.

4.C.1 Continuous Chemical Engineering Program Improvements

The curriculum has undergone revision and improvement in the last six years in response to feedback from these assessment tool, faculty initiatives, changing university requirements, new ABET rules, and other sources. New degree requirements have been implemented and others have been revised during this period. These changes were based on a combination of faculty initiatives and input from both external and internal assessments. The most significant changes are:

- Biology in the curriculum
- Instructional use of computing software
- Professional Breadth elective
- Advising improvements
- Process hazard awareness
- Assessment program sustainability
- Statistics preparation

The individual sections highlight the need for improvement identified from constituency and assessment tool inputs and the action taken to address this need. Subsequent monitoring determines whether the desired improvement has been achieved; if not, further actions are taken and evaluated for effectiveness. In two of these areas, follow-up action has been indicated and is underway. The process by which these changes are implemented is the responsibility of the Curriculum Committee, although in practice the Chair often appoints an *ad hoc* committee of the most interested faculty to bring the highest expertise to bear on a specific problem.

4.C.1.a Biology in the curriculum

While many chemical engineering students have long chosen biological electives, in 2004 the department added 2 courses (6 credits) of biological sciences to the degree requirements in response to many inputs. These included Alumni Survey and Engineering Career Services employment data showing the growing fraction of our graduates being employed by the food, pharmaceutical, and biotechnology industries, other constituency feedback, and faculty assessment of growth in chemical engineering application fields. The 2006 ABET Self Study describes in detail how an *ad hoc* committee of Profs. Abbott, Murphy, Palecek, Shusta, and Yin considered inputs from our many constituencies and assessment tools, explored options, and determined to add Biochem 501 – Introduction to Biochemistry and Zool 570 – Cellular Biology to the curriculum as replacements for the Advanced Chemistry Elective and Chemistry Lab Elective requirements.

After monitoring the impact on the undergraduates for several semesters the course choices were assessed. Feedback from students obtained through advisors combined with evaluation from the biology course faculty led the department to conclude that these courses were not attaining the desired goals. Biochem 501 impact was satisfactory. Indeed, this course had already been the most common selection from the recommended options for the Advanced Chemistry Elective. Zool 570 was determined to be inappropriate as a requirement for all chemical engineering undergraduates. While it had been successful as an upper-level elective for a small number of biologically inclined undergraduates, the course faculty reported that most chemical engineering students lacked necessary biological background and were not performing well. The ad hoc faculty group returned to consideration of introductory courses (Zool 101 – Animal Biology and Zool 151 – Introductory Biology) that had not been chosen earlier. Discussion with the core biology faculty responsible for these courses determined that the topics in Zool 151 – Introductory Biology were most appropriate. This 5-credit course contains a laboratory designed for students majoring in biological sciences which was not desirable for engineering students (both from student effort and course resource viewpoints), so a modified, 3-credit class and recitation-only version was created as Zool 153 to provide this material to the engineering audience through simultaneous registration. With this new introductory course available, the upper-level biology course was opened up to include other suitable options.

In 2007 the new Introductory Biology requirement was established to be Zool 153 (or 151 or AP Biology with a score of 5) and an Advanced Biology requirement, with a choice among Biochem 501 – Introduction to Biochemistry, Genetics 466 – General Genetics, Microbiology 303 – Biology of Microorganisms, or Zool 570 – Cell Biology. The curriculum was rearranged to place the Introductory Biology course in the freshman year with the benefit of being able to use more biological examples and problems in chemical engineering courses at all levels. Feedback from students, advisors, and course instructors has been uniformly positive about this refined version of the biological sciences requirement. Regular communication between instructors in Zoo 153 and CBE faculty continues. For example, recently Zoo 151/153 faculty are considering some changes in course content and consulted with CBE about the impact of these changes on our students. These changes are in fact advantageous, as lectures on evolution will be replaced with lectures on physiology. Thus, biology concepts taught in this introductory class are now even better aligned with those topics of most interest to chemical engineers.

4.C.1.b Instructional use of computing software

Feedback from students, alumni (through the Alumni Survey), and higher-level chemical engineering instructors (through Instructor Course Evaluations) led to the conclusion that specialization of computer lab applications and homework problems to more relevant problems would greatly help students prepare to use these skills in their major discipline classes. Implementation of a suitable introductory computing course to establish skills with programming methods and software suitable for application in the program has been an ongoing problem. Instruction in the conventional Comp Sci 310 had been taken on by an Engineering faculty member and converted to an online presentation covering MatLab and applications suitable for generic engineers early in the decade. This problem was noticed by several of the engineering programs using this course, so in 2007 Prof. Rawlings undertook a collaborative project with colleagues in engineering mechanics and civil engineering. With funding from a COE Technology-Enhanced Learning program they explored use of shared recorded lectures and discipline-specific applications and problems. His new course designed around online lectures and CBE-specific computer laboratory sections was tested with several small groups of students using the CBE 562 –

Special Topics developmental course title and approved as a substitute for Comp Sci 310. The new delivery treatment received high acceptance from the trial student sections. The new course, CBE 255 – Introduction to Chemical Process Modeling, in 2009 replaced Comp Sci 310 – Problem Solving Using Computers. The new CBE 255 course was approved by the university and incorporated in the CBE curriculum for students entering the major in fall 2009.

This new course works very well, but there are two aspects noted that will be considered for future modification. First, students comment to advisors that some of the chemical engineering examples in the online modules are not well matched with the lack of engineering sophistication of the present 4^{th}-5^{th} semester students. Discussions are underway with the 255 instructors and the Curriculum Committee as to whether modifying example content or shifting location in the curriculum is more appropriate. Second, transfer students and others who substitute Comp Sci 310 for CBE 255 lack Matlab expertise that is now expected by faculty teaching in CBE 470, 430, and other courses. This is documented in Instructor Course Evaluation forms, as mentioned above in section 4.B.4 regarding Student Outcome (k). Advisors are now recommending CBE 255 as a chemical engineering elective for students not using it as the required course, and discussion is underway between the upper level instructors and the Curriculum Committee investigating possibilities to provide a remedial module for transfer students or if restricting substitution for CBE 255 is more appropriate. The Matlab introduction material from CBE 470 that was removed from the course is being revised for presentation as an online supplement to be available for any students in need of remedial material or a refresher mini-course. Assessment of impact on CBE 430 and 470 Matlab use will be conducted for two semesters after implementation of the online supplement.

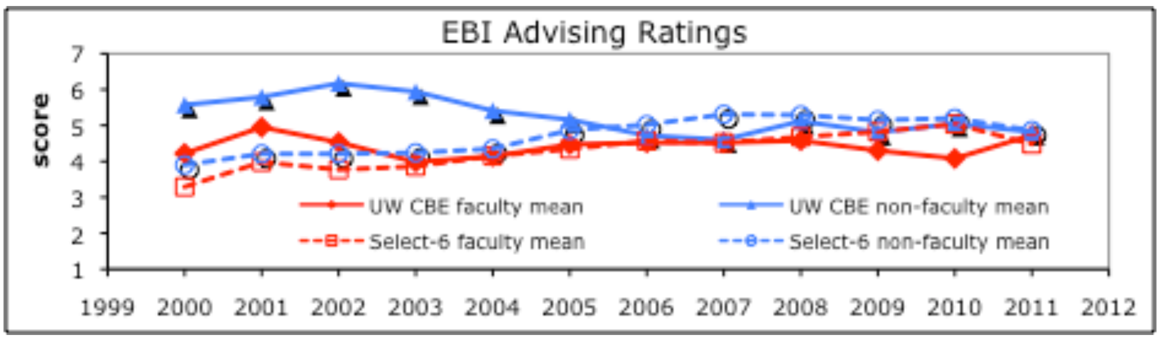
4.C.1.c Professional Breadth elective

Restricted electives in the curriculum are intended to allow students to individualize the program to provide depth in a particular interest area or breadth across application fields. Feedback from the Alumni Survey consistently showed that the required ECE 376 – Electric Circuits and Electronics course was not useful. Also, many students told advisors that they desired more flexibility to take useful electives in chemistry, business, or other fields beyond the previous range of Engineering Electives. Cumulative changes in core departmental required courses have now resulted in sufficient credits required in CBE courses to satisfy the ABET Engineering Topics requirement without restricting additional electives to be within Engineering.

Data from placement statistics and from Alumni Survey employment responses shows that graduates apply their degrees in a very diverse range of disciplines. In response to dissatisfaction with ECE 376, and in order to accommodate the need for increased flexibility, the department instituted a 6-credit Professional Breadth Elective requirement in 20xx. Courses that satisfy the professional breadth requirement include courses numbered 300 or higher from the College of Engineering (excluding CBE courses), courses numbered 300 or higher from the Departments of Chemistry, Physics, Computer Science, and Mathematics, as well as a variety of other courses on an approved list. Students can petition to add to this list courses that will enhance their careers as engineers. Many students use this elective to take courses from other engineering disciplines. A significant number of students enrich their backgrounds with second majors in useful fields, obtain certificates with interdisciplinary specialization (Biology in Engineering, Technical Communications, Energy Efficiency, Technical Japanese, or many others), or follow other individual interests. The broadening of the scope of the Professional Breadth electives permits students to prepare for many different fields of employment after graduation and to accomplish this partially within the scope of the chemical engineering degree. This additional flexibility is broad enough to create some planning uncertainty among students newly declaring the chemical engineering major. The breadth requirement thus has the benefit of encouraging thoughtful discussions with advisors about career goals and use of elective flexibility to prepare for different career pathways. Conversations with alumni and with entering HS seniors and engineering freshmen show that the additional flexibility is generally viewed as a benefit.

4.C.1.d Advising improvements

Student advising is a very visible component of the program and one that has attracted continued scrutiny in the department and across the college. EBI Exit Survey results show moderate dissatisfaction with both faculty and non-faculty advising. The scores shown are in the action area below 5 on the 1-7 scale, and compare unfavorably in recent years to the Select-6 peer group scores for both categories. The most recent scored are right on target with the peer comparison.



Focus-group discussions with students have been called several times to provide additional detail and insight. To address advising concerns, there have been a number of innovations by the department. Other tools made available by the College or the University provide additional assistance.

EAGLE: development of graphical DARS presentation for advising use. This flowsheet-based template for displaying transcript information can assist students in recognizing prerequisites, planning multiple semesters, and identifying missing requirements.

Advisor assignments: Faculty advisors have the primary responsibility for both career advising and academic advising. Problems with advisor compatibility and availability were addressed in several ways. Students now can choose advisors when declaring the major instead of being assigned by alphabetic roster. This allows them to pick based on research or application expertise, personal factors, or for other reasons. The advisor list had contained all faculty except the chair, as a way to maintain high involvement of all faculty with undergraduates. This list was decreased, excusing the center directors, and other faculty with limited availability to increase responsiveness of the listed advisors and maintaining involvement of more than half of the faculty and spanning the full range of student interests.

Online Curriculum Guide: This listing of degree requirements had always been provided on paper and as a PDF file on the department web site. It is now available as a linked series of pages for more convenient use by students.

Academic staff advising: An additional staff member was added to augment undergraduate advising. Faculty Associate Andrew Greenberg (Ph.D., Chemical Education) oversees REU activities, undergraduate non-classroom programs, and advising responsibilities for academic issues. This will improve turnaround on course and curricular questions and permit a larger fraction of faculty advising to address job prospects and career planning issues.

Group entry advising: Small-group meetings are regularly scheduled for newly-admitted CBE students to provide an overview and orientation for the curriculum. These sessions have received high acclaim from the new students and have decreased the frequency of mid-program advising misunderstandings.

Drop-in advising: Experienced faculty advisors now provide one or more half-day open advising periods each. These come after the Advising Week period where students may have individual meetings with their advisor and provide a back-up opportunity to make advising contact and have advising holds removed before course registration opens.

Course renumbering: The first-semester thermodynamics course number was changed from CBE 211 to CBE 310 to better indicate its appropriate location after the CBE 250 introductory course. This is expected to prevent several registration misunderstandings each year.

Smaller improvements also underway have been undertaken by several personnel mentioned above. Collectively, these changes appear to be beginning to affect the advising scores in the EBI Exit survey and the informal feedback received through student organizations. Feedback from these sources will continue to be monitored.

4.C.1.e Process Hazard awareness

Awareness of hazards associated with chemical engineering processes is already integrated throughout appropriate courses in the UW CBE curriculum. In response to the new Program Criterion wording explicitly including process hazards, the department has instituted assessment of process hazard content and undertaken a new initiative to extend coverage.

Documenting awareness of process hazards associated with chemical engineering processes is a priority area. In spring 2011, EAC guidelines presented the recommendation for adoption of the Chemical Safety Board recommendations for increased emphasis in undergraduate curriculum, and in October 2011 the revised wording for the Program Criterion was approved in final form. During the fall semester an inventory of chemical engineering core courses by the Assessment and Curriculum Committees showed that process hazard awareness was contained in a broad range of courses at different levels and frequencies. This collection of exposures, exercises, and activities was found to cover many aspects and to vary from good to excellent from instructor to instructor. Comparison with the Safety and Chemical Engineering Education (SAChE) list of recommendations for ABET safety content showed that courses regularly covered four of the eight suggested options for process hazard education, and provided partial coverage of others.

Information collected on how peer institutions and the broad range of chemical engineering undergraduate programs cover process hazards showed a variety of approaches. Most chemical engineering departments provide distributed coverage of process hazards with treatment of particular safety, control, and process issues integrated into appropriate unit operations courses to provide immediacy and to closely couple the hazard awareness with the corresponding chemical process technology. Discussion with academic members of the Visiting Committee in November 2011 (representing Delaware, MIT, Princeton, and UT-Austin) determined that the dominant model in these leading departments with broad missions and goals for their alumni strongly favored the distributed model. Since this model is consistent with the current course structure at UW-Madison and would not require creation of a new course at the expense of reclaiming the credit hours from the existing, fully loaded curriculum, the consensus plan is to strengthen the process hazard coverage within present courses.

Existing activities:

- UW Safety Department training and certification in CBE 324 laboratory
- "Accidental Risks" video (Bhopal in America) and discussion
- Reaction exotherm, adiabatic temperature rise, and reactor runaway in CBE 430
- Toxicity and Life Cycle Analysis in CBE 440
- Coverage of CSB accident report videos in CBE 450
- Coverage of Inherently Safe Design in CBE 450 some semesters
- Coverage of infamous chemical industry disasters – in many courses

Enhanced activities:

- Web-based presentation of "Accidental Risks" video and discussion activity
- Safety Audit of Informal Experimental plans in CBE 424
- Coverage of T2 accident CSB video in CBE 430

Additions under consideration:

- Integration of Inherently Safe Design into CBE 450 all semesters
- Improved introduction to Hazops and other regulatory frameworks
    - Consideration of variations between industries
    - Determination of appropriate generality for graduate career diversity
- Review and adoption of SAChE online training resources

These discussions will be continued in the Assessment Committee and the Curriculum Committee in the summer and fall of 2012. Further recommendations for implementation of new features agreed upon by instructors for CBE 450 or corresponding core instructor groups in other courses will be presented to the faculty at faculty meetings. After adoption, they will be established with Performance Indicators to allow assessment and evaluation of their impact. Results of these assessments and the instructor comments on the Instructor Course Evaluations over the following semesters will permit modification if needed for further refinement.

4.C.1.f Assessment program sustainability

We have been prioritizing and streamlining to reduce the pre-2006 list of 17 primary, secondary, and tertiary tools to the two direct measures and five indirect measures described in the evaluation analysis described in above sections. Other tools are still available, and are used as supplements if needed or are noticed in exceptional cases. Before 2006, an ABET review expressed a concern that the extensive assessment program in effect then was not sustainable. This focus on a sustainable core of assessment tools occurred in 2006 for the previous ABET visit. The suggestions of the Assessment Committee were provided to the Curriculum Committee, and the combined perspectives were presented to the faculty at a series of faculty meetings for discussion and ratification early in the current cycle.

Further improvements of the assessment program will involve simplification of the rating scales in use. At present different tools use at least 5 scales (EBI 1-7, Co-op Eval BE-ME-EE, Performance Indicators P/F, U-M-S, and 1-5, Student Course Evaluations 1-5). These scales and assessment tools have been in continued use since 2004, and their use was continued through the 2012 ABET review to avoid introducing uncertainty in interpretation that would accompany any scale change mid-cycle. These scales do create corresponding difficulties both in application by faculty and in interpretation by the department. Calibration of different scores varies by different user groups, with the EBI scorers (students) and Co-op evaluators being independent of department direction. However, there is general support for simplifying and improving the scoring of the Performance Indicator measures. The P/F scale is widely acknowledged as unsatisfactory and providing little useful feedback for program improvement. For the next cycle we plan to replace the P/F scale with one of the other scales. This was already switched to the U-M-S scale in CBE 250 and 450 as seen above in 4.B. The Unsatisfactory-Marginal-Satisfactory scale suffers from poor definition of Marginal, and there is support for replacing it with the Co-op Evaluation scale of Below Expectation-Meets Expectation-Exceeds Expectation. This provides both an error signal below the center and a superior indicator above the expected performance level, and allows definition of the expected performance at a reasonably high level below perfection. The 1-5 scale is under discussion to refine the meaning of different levels, perhaps with the help of more written rubrics for selected applications.

The assessment data collection and documentation process is also difficult and unsustainable. We will compare best practices between departments to generate additional improvements. The College of Engineering has been exploring the use of the AEFIS program, which is commercial software package designed for course management, evaluation, and improvement, assessment data collection, and other documentation purposes with strong relevance to ABET reviews. This program is now in limited use for preparing some review materials, and may provide a framework for maintaining the assessment tools and results in future review cycles.

The frequency of application of different assessment tools is a focus of our discussion of assessment. Current practice collects some tools every semester, while others are collected as infrequently as every 3-4 years. Tools such as the EBI survey have a natural annual cycle, but some peer institutions use it only in alternate years. Large variability is seen from observation of different data collection cycles in other departments at UW and practices at other peer institutions. Based on experience and feedback from the upcoming ABET visit, there is strong interest in reviewing the application schedules for our ongoing assessment tools.

Administration of the Alumni Survey is also being improved, as described in the tool definition section of 4.B.1. The frequency of twice every six years is to be maintained while shifting to use in the 2^{nd} and 5^{th} years of each ABET review cycle. Future survey analysis will pay particular attention to response rate to determine if recent concern over a possible decrease is transient or is a growing problem.

After the 2012 review, the department will re-evaluate to gain insight into which tools and scales are most useful and which need improvement. The department will refine the assessment system in Spring 2013 based on post-visit discussion and recommendations by the Assessment Committee and the Curriculum Committee.

4.C.1.g Statistics preparation

Improvement of statistics preparation is a new initiative begun in spring 2012. Several assessment tools have indicated a need for strengthening the statistics expertise of program graduates. In the PEO analysis of *Objective 1: Foundation* in section 4.A, results of Alumni Surveys identify use of statistics as an area where graduates identify a need for better preparation early in the career. The environmental plots of technical skill areas show 'statistics' to be farthest off the 45° preparation/usage equity line in each of the last three Alumni Surveys. In Student Outcome analysis of *Outcome k – ability to use the techniques, skills, and tools of modern engineering*, the Co-op/Intern Evaluation comments have multiple mentions of need for more familiarity with statistics. The Curriculum Committee has met to identify possible actions to address this area of need. Discussion at upcoming faculty meetings will result in identification of a small working group of interested faculty to form an *ad hoc* Statistics committee that will recommend action in a process similar to that used by the *ad hoc* Biology committee described above in 4.C.1.a.

Feedback from several inputs will be used to inform this improvement. The 2012 Alumni Survey had questions added to further explore statistics use by alumni, and multiple responses identified common areas ranging from uncertainty analysis to ANOVA, Design of Experiments and Six Sigma formalisms. Interviews with instructors and supervisors of the current Stat 324 – Applied Statistics for Engineers course provided information on how this course and related service courses have changed since originally designed around 1995, and how they have modernized with new textbooks and computer tools. Statistics use in chemical engineering laboratories (CBE 324 and 470) and courses is being reviewed and opportunities for more use of statistical tools will be identified. Input from corporate interviewers will be solicited to better understand statistics use in different industries. This initiative will also monitor a college working group (members of Nuclear Engineering, Chemical Engineering, and Industrial and Systems Engineering, with support from Bayer AG) developing a Certificate program in Risk Assessment for undergraduates, since this group is also considering course modification or new course development in this area combining our increased level of activity in both Process Hazard Analysis and statistical skills. The department faculty will be discussing what changes are desired in supporting courses and what changes in implementation and usage would be suitable in applicable chemical engineering courses.

After the *ad hoc* Statistics working group selects desired curricular actions, the impact of the improvements will be monitored through the assessment tools. A Performance Indicator relating to specific statistics content will be added to the collection and measured each semester to gain rapid feedback on impact on current students and student outcomes. Alumni Survey administration in 2014 will be too soon to show results of any upcoming change, so the 2017 survey will be more suitable for closing the loop on PEO impact among the alumni.

4.C.2 College-wide Continuous Improvement Efforts

4.C.2.a Engaging students, faculty and industry stakeholders in continuous improvement.

The College of Engineering has and continues to develop an on-going process of continuous improvement through innovation in engineering undergraduate education. This effort, embodied in the Engineering Beyond Boundaries initiative, has been active since at least 2005. The Engineering Beyond Boundaries initiative is a college-level effort that has impacted every undergraduate program in the college. It is led by an Engineering Beyond Boundaries Task Force consisting of seven faculty (one from CBE) and staff, including the Dean and the Associate Dean of Academic Affairs, who determine strategic direction. The goal of the initiative is to provide a contemporary engineering education that is strong in the fundamentals of the discipline and also fosters an understanding of the societal context of engineering and a passion for life-long learning. This will be achieved by guiding students through new educational opportunities to:

- build disciplinary excellence with multidisciplinary perspective,
- nurture critical thinking,
- develop multicultural competence,
- cultivate collaboration and leadership skills, and
- promote an ethic of service to the profession and the community.

In 2007, the Engineering Beyond Boundaries Task Force solicited pilot projects to free faculty time to pursue the objectives identified above. In the first year, twenty projects were funded using designated funds and covering a wide range of topics from international experiences to new freshmen engineering courses to technology enhanced learning. Some of the initiatives seeded by the first year of this program remain active today. For example, one project enabled a faculty member to develop a freshmen engineering course founded on interdisciplinary approaches to solving the National Academy of Engineering's Grand Challenges and with the premise that altruistic efforts of engineers can attract new students to the field of engineering. In-course assessment showed this course was particularly successful in increasing retention of diverse students in engineering majors, and also showed it to improve student awareness and competency in student outcomes such as teamwork, awareness of global impact of engineering solutions, lifelong learning, and professional and ethical responsibility. After a successful debut, the pilot course was formalized in the College of Engineering. It then received campus funding to more than double in size and enroll a broader campus-wide audience of students. It also formed the premise of a proposal to NSF to develop similar modules for middle school students and was ultimately funded for three years. This project along with those involving international study and technology-enhanced learning have had widespread impacts on undergraduates in each program.

To grow and sustain the EBB effort, new strategies were developed to engage students, faculty, and industry via the College of Engineering Industrial Advisory Board. These strategies included:

- engagement with student concerns through meetings and interviews with Polygon, the Engineering Student Council that represents all undergraduate engineering students;
- direct feedback from COE undergraduates through Polygon surveys and inclusion of students in COE roundtable discussions;
- development and implementation of an undergraduate COE differential tuition plan to fund needs identified by the students and the College;
- refinement of the goals of EBB with input received from the College of Engineering Industrial Advisory Board
- integration of EBB strategies into the strategic plan for the College;
- facilitation of assessment and continuous improvement through the purchase and initial implementation of a College-wide sustainable assessment process using AEFIS software.

The COE gathered feedback over the past six years through ongoing meetings with Polygon, the Engineering Student Council that represents undergraduate students in COE. In September 2006, Polygon student leadership was asked to provide input on changes COE students would like to see in their academic experience in COE. The purpose was to engage undergraduates in helping guide educational improvements. Polygon student leaders met with representatives from the 34 recognized student organizations in COE and developed the following list of five student high priority needs, as follows: 1) improve hands-on learning experiences, 2) develop a uniform COE policy for awarding technical electives for student organization involvement, 3) improve supplementary instruction, 4) facilitate formal degree opportunities to broaden education, and 5) strategically reform curriculum to enhance its relevance for engineering careers.

To enable a meaningful response to these and other undergraduate needs, the college began to discuss implementing a differential tuition in 2007. It became clear it would be difficult to sustain the innovation and achieve our objectives with the decline in state funding for higher education. The proposed tuition differential had three objectives: 1) facilitate a high quality learning experience and engineering education to meet the needs of the 21st century, 2) reduce the time to degree by improving student through-put, 3) increase the number of engineering graduates per year. During the 2007 calendar year the topic was actively discussed between the student body and the college administration. Using peer-to-peer discussion groups and open invitation informational sessions led by college administration, students became informed on the services they could expect from the differential. As the knowledge of differential tuition increased, so did the support.

In the Spring of 2007, the Polygon Student Council supported the concept and need for a College of Engineering differential tuition. In a subsequent meeting, they voted to support phasing in the Engineering Specific Tuition over a 3-year-period in amounts not exceeding $300, $500, and $700 per student per semester. This initiative came to the Univ. of Wisconsin System Board of Regents in June 2008. The Regents' Business, Finance, and Audit Committee first considered the matter and voted unanimously (including student regents) to recommend the proposal endorsed by Polygon. The proposal passed the full Board of Regents unanimously on June 6, 2008.

Two advisory committees were subsequently formed to advise on the dispersion of the revenue; both remain active to this day. One committee consists entirely of students to provide recommendations and to screen student proposals. The other, known as the College of Engineering Differential Tuition Advisory Committee, consists of two faculty, two staff, and two students who review expenditures and provide recommendations.

Funds have been expended in the categories listed in Table 4.C.2. In 2010-11, $1.8M was dispersed under this program. Category 1 expenditures provided expanded capacity in required courses and majors. In the Spring of 2010 for example, over 700 additional seats in 35 courses and 8 departments were opened to students awaiting access to those courses that were otherwise filled to capacity. Category 2 directly addresses concerns originally expressed by students to improve hands-on educational opportunities. This has taken the form of equipment upgrades in undergraduate laboratories, a total refurbishing of the College of Engineering student shop, and an expansion of access hours to that shop. Category 3 has provided funds to support advising with an expanding enrollment and the student leadership center. Category 4 has supported instructional innovation as targeted by the Engineering Beyond Boundaries effort.

Table 4.C.2. Distribution of CoE differential tuition funds

Category	2008-2009	2009-2010	2010-2011
1. Instruction (classroom)	32%	40%	46%
2. Instruction (labs & hands-on)	40%	30%	30%
3. Student Services	11%	15%	12%
4. Instructional Innovation	15%	15%	11%

In February 2011, Polygon reaffirmed the need for a College of Engineering differential tuition. In the same month, a differential tuition roundtable of seven students, four faculty and two staff met for a half day to consider educational delivery in the College of Engineering. They recommended that the College of Engineering needs to accelerate its adoption of technology in teaching with efforts to achieve 1) a broad and pervasive use of online lecture materials, online quizzing and electronic textbooks, 2) more training related to state of the art software tools, and 3) infrastructure improvements related to printing and remote software access.

The recommendations of the students were reviewed with the College of Engineering Industrial Advisory Board in April of 2011 and they endorsed accelerating the adoption of technology in teaching. They were engaged again in October of 2011 in reviewing a draft of the strategic plan, which called for incorporating online lecture materials in 50% of the college's required courses over the next 5 years. In its monthly meeting of November 2011, the College of Engineering's Academic Planning Council (APC) considered updates to the College of Engineering draft Strategic Plan. After considerable discussion of both the student and IAB recommendations, the APC changed the "50% of core courses" to "75% of core courses." The revised Strategic Plan was unanimously approved in the same meeting.

From 2010 to the present, the EBB projects have been focused on achieving the strategic plan. Leveraging other sources of funds, the college is well on its way to achieving its strategic goal of offering 75% of the undergraduate core courses in a blended format by 2017. In addition to the projects, resources have been realigned to achieve this objective. In early 2010, Wendt Library was renamed Wendt Commons and became a new facility that includes a teaching and learning center staffed with experts on making the technological and pedagogical changes needed to effectively incorporate technology in a blended learning environment. The space was remodeled for novel hybrid learning spaces and student group tutoring.

4.C.2.b Implementing a Systematic, College-wide Assessment Tool.

In 2011, the College of Engineering entered into a license agreement with UNTRA Academic Management Systems for their AEFIS 3.0 software (http://www.goaefis.com/) and agreed to participate in their AEFIS 3.0 Pilot Program. This software originated from a NSF project conducted in the Drexel College of Engineering to develop a systematic approach to the ABET accreditation process. The software is a developing product from a new startup company but is in use at a number of other institutions globally. Because of the developing nature of the software, AEFIS can be customized to meet our needs.

The goal in implementing the AEFIS software is to streamline the program assessment data collection process to enable greater emphasis on data analysis and teaching improvement. AEFIS 3.0 is being integrated with campus databases to greatly reduce the need to enter redundant information related to both indirect and direct measures of outcomes and to collect the data into one comprehensive tool. There are four levels of implementation to the software as follows:

Level 1: Survey tools and course evaluation tools
Level 2: Level 1 plus syllabi repository (involves developing course objectives for indirect assessment)
Level 3: Level 2 plus Academic Program Management (create and manage student learning outcomes)
Level 4: Level 3 plus Direct Assessment Measures Management (enter and link direct measures with student outcomes)

We are currently at a partial Level-2 implementation. After considerable start-up effort that involved gaining the cooperation of the Registrar and the Division of Information Technology here on campus, COE has installed AEFIS 3.0. Course timetable and roster information is uploaded into the AEFIS system and updated on a daily basis. In the first year of the contract, we were able to successfully load from campus databases all engineering course information and course roster data into the AEFIS system. We had the AEFIS software modified to accept the campus net-ID for login and we ensured updates were in place of underlying software to meet college and campus security requirements. We have been able to offer student course evaluations in two COE departments. The number of staff hours to conduct course evaluations drops by approximately two orders of magnitude versus paper evaluations by this approach. This new software offers the potential to craft student course evaluation information and integrate it automatically in meaningful course assessment and evaluation of student outcomes. We have only scratched the surface of possibilities in assessment as we have begun to implement this tool. With initial staffing, during the past year we have gained local expertise in the use of the tool.

Our four-year goal is a full level-4 implementation for all undergraduate degree programs in the College of Engineering and with additional time some inclusion of select graduate degree programs, although the graduate level assessment is not required for our undergraduate assessment. After one year, we have not encountered any difficulties that make this goal unachievable or unreasonable. In addition the UNTRA staff have been extremely helpful, and proactively motivated by the common goal of a successful implementation at UW-Madison. We seek to integrate Biological Systems Engineering courses in the coming year and our core math and science courses into the AEFIS system in future years. Our overall goal is to use the AEFIS online tool as we continue to develop and motivate a culture of standardized and sustainable student assessment. The University Assessment Council has been supportive both financially and procedurally in this shift in our approach to assessment as they wait to see the implications of a broader campus adoption of our approach. While the AEFIS implementation has played only a minor role in this particular ABET review, this development indicates our future direction in assessment.

Continuous improvement in the college is developing both at the program level and at the College level with support from the University. Although it remains a work in progress, we are pleased with both the progress and with the direction that our assessment efforts are headed.

4.D Additional Materials Available for Review at Visit

The assessment materials will be available for inspection. Summary reports on alumni surveys, exit interviews, etc. will also be available. Most of the following materials are available on the CBE assessment website and available for advance viewing. The bulk of the original material (semester reports, examples of student work, etc.) is on a department file server and available for viewing during the visit. If requested, we may be able to enable the file server for remote access in advance of the visit. The materials that will be available for review during the visit are as follows:

- Co-op/Intern Supervisor Ratings – evaluation form, raw data and semester summaries (2002-2011)
- Performance Indicators from selected courses (2004-2012)
- Alumni Survey Full Analysis of Results (1996, 2001, 2004, 2007, 2012)
- EBI Exit Survey Results– full results and summaries (2001 – 2011)
- Engineering & Career Services Job Placement Statistics
- Student Course Evaluation Student Outcome (a-k) scores (2001-2012)
- Instructor Course Evaluations (2007-2012)
- Visiting Committee Reports (2001 – 2011)
- Web site publication (assessment.che.wisc.edu)
- Related materials stored on department server Assessment partition

Miscellaneous

- Faculty meeting minutes
- At the reviewer's request

CRITERION 5 - CURRICULUM

5.A Program Curriculum

The goal of the Chemical and Biological Engineering faculty is to develop each student's knowledge of chemical engineering principles, and his/her ability to apply these principles towards analysis and synthesis of chemical processes and products. The faculty assures that the curriculum devotes adequate attention and time to each curricular component area. Basic science and math studies are combined with fundamental courses in chemical engineering and other forms of engineering. Flexibility to customize in areas of special interest, such as energy and sustainability, bioengineering, or entrepreneurship, is provided by several categories of restricted electives. Additionally, each chemical engineering student selects a sequence of courses in liberal studies. This academic balance is necessary because the success of chemical engineers depends upon a broad-based educational background and an understanding of society, together with scientific and technological competence.

5.A.1 Plan of Study

The standard-form description for the current curriculum (for students starting in the major in January 2009 or later) is included in Table 5.1. The 2009 requirements are in force for most 2012 graduates as well as the large majority of continuing students. [Students who declared the major before January 2009 may be working under the prior 2007 curriculum, may substitute some of the newer requirements, or may opt for the 2009 curriculum in entirety. These students may have had multiple co-op semesters or other interrupted study timelines.] The principal changes between the 2007 and 2009 curriculum include: changes in the biology course requirement, replacement of CompSci 310 with CBE 255, and conversion of the Engineering Elective to the Professional Breadth Elective. Descriptions of these changes are in 4.C – Continuing Improvement.

5.A.2 Relationship of Curriculum with Program Educational Objectives

The curriculum supports the Program Educational Objectives through its broad coverage of the many attitudes, expectations, abilities and techniques needed to position our graduates to pursue those objectives. The curriculum is an integrated blend of coursework and experiences that is carefully designed to achieve the desired Student Outcomes. Individual courses are woven together into the cumulative experience provided by our program. Our curriculum provides a broad-based liberal education in mathematics, physical sciences, biological sciences, social sciences and humanities. The engineering curriculum begins with design, teaches the foundational engineering sciences,

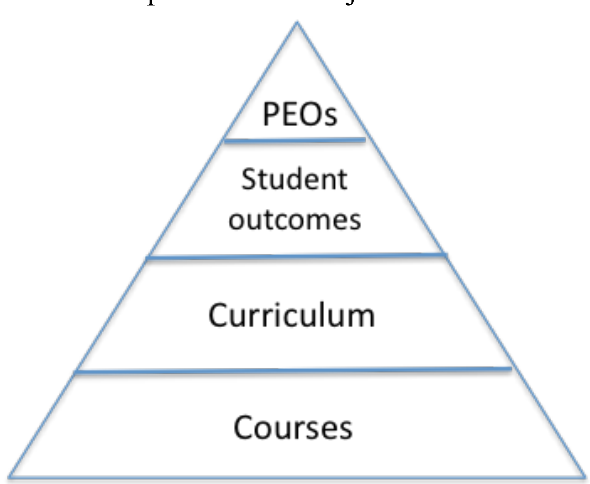


Table 5.1 Curriculum

Chemical Engineering, UW-Madison

Course (Department, Number, Title) List all courses in the program by term starting with first term of first year and ending with the last term of the final year.	Indicate Whether Course is Required, Elective, or a Selected Elective by an R, an E or an SE.[1]	Subject Area (Credit Hours)				Last Two Terms the Course was Offered: Year and Semester	Maximum Section Enrollment for the Last Two Terms the Course was Offered[2]
		Math & Basic Sciences	Engineering Topics Check if Contains Significant Design (√)	General Education	Other		
Freshman Term 1							lecture/recitation
Chem 109 – Advanced General Chemistry	R	5				F'11, S'12	288/13
Math 221 – Calculus and Analytic Geometry	R	5				F'11, S'12	239/23
Communications Elective	SE			2		F'11, S'12	20
Liberal Studies Elective	SE			3		F'11, S'12	25[3]
Freshman Term 2							
Chem 329 – Fundamentals of Analytical Science	R	4				F'11, S'12	62/8
Math 222 – Calculus and Analytic Geometry	R	5				F'11, S'12	238/18
Physics 201 – General Physics	R	5				F'11, S'12	243/11
Liberal Studies Elective	SE			3		F'11, S'12	25[3]
Sophomore Term 1							
CBE 250 – Process Synthesis	R		3 √			F'11, S'12	54
Chem 343 – Introductory Organic Chemistry	R	3				F'11, S'12	319/23
Math 234 – Calculus – Functions of Several Variables	R	3				F'11, S'12	199/19
Physics 202 – General Physics	R	5				F'11, S'12	220/18
Zool 153 – Introductory Biology	R	3				F'11, S'12	480/40

Sophomore Term 2							
CBE 255 – Introduction to Chemical Process Modeling	R		3			F'11, S'12	56/12
CBE 310 – Chemical Process Thermodynamics	R		3			F'11, S'12	50/25
Chem 344 – Introductory Organic Chemistry Lab	R	2				F'11, S'12	133/24
Chem 345 – Intermediate Organic Chemistry	R	3				F'11, S'12	23
Math 319 – Techniques in Ordinary Differential Equations, or Math 320 – Linear Algebra and Differential Equations	SE	3				F'11, S'12	198/22 210/18
Stat 324 – Intro. Applied Statistics for Engineers	R	3				F'11, S'12	23
Junior Term 1							
CBE 320 – Introductory Transport Phenomena	R		4			F'11, S'12	76/25
CBE 311 – Thermodynamics of Mixtures	R		3			F'11, S'12	48/22
Advanced Biology Elective	SE	3				F'11, S'12	490
Liberal Studies Elective	SE			3		F'11, S'12	25[3]
Professional Breadth Elective	SE			3		F'11, S'12	varies widely
Junior Term 2							
CBE 324 – Transport Phenomena Lab	R		3			F'11, S'12	16
CBE 326 – Momentum and Heat Transfer Operations	R		3			F'11, S'12	56/28
Chem 562 – Physical Chemistry	R	3				F'11, S'12	90/30
Liberal Studies Elective	SE			4		F'11, S'12	25[3]
Professional Breadth Elective	SE			3		F'11, S'12	varies widely
Senior Term 1							
CBE 426 – Mass Transfer Operations	R		3 √			F'11, S'12	57/29
CBE 430 – Chemical Kinetics and Reactor Design	R		3			F'11, S'12	56/28
Chemical Engineering Materials Elective	SE		3			F'11, S'12	55
CBE Elective	SE		3			F'11, S'12	varies widely
Liberal Studies Elective	SE			3		F'11, S'12	25[3]

Senior Term 2							
CBE 450 – Process Design	R		3 √			F’11, S’12	56/20
CBE 470 – Process Dynamics and Control	R		3			F’11, S’12	60/16
CBE Elective	SE		3			F’11, S’12	varies widely
Free Elective	E				6	F’11, S’12	varies widely
Senior Summer Session							
CBE 424 – Operations and Process Lab	R		5 √			Summer ’11, ‘12	37
Add rows as needed to show all courses in the curriculum.							
TOTALS-ABET BASIC-LEVEL REQUIREMENTS		55	48	24	6		
OVERALL TOTAL CREDIT HOURS FOR COMPLETION OF THE PROGRAM	128+5						
PERCENT OF TOTAL		40.6%	37.5%				
Total must satisfy either credit hours or percentage	Minimum Semester Credit Hours	32	48				
	Minimum Percentage	25%	37.5 %				

1. **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group.
2. For courses that include multiple elements (lecture (L), laboratory (l), recitation (r), etc.), indicate the maximum enrollment in each element. For selected elective courses, indicate the maximum enrollment for each option.
3. For electives, an average across typical choices is indicated.

Instructional materials and student work verifying compliance with ABET criteria for the categories indicated above will be required during the campus visit.

progresses through courses to develop specific engineering skills, and culminates with integrative design and laboratory experiences. Contributions to individual PEOs can be seen in many of the courses. The curriculum is designed to progressively develop and deepen the interests, attitudes, and skills of our students so that at graduation they are prepared for continued independent growth while they are establishing their careers.

5.A.3 How Curriculum Supports the Attainment of Student Outcomes

Most courses in the curriculum contribute to attainment of multiple Student Outcomes. Table 5.2 below shows the strength of these linkages for the required CBE courses. Note that this grid is a superset of the Performance Indicators documented above in Criterion 4, and those Performance Indicators are only a sampling of the many activities where students develop and practice the outcomes. Here we now present a narrative of the progression of courses that are particularly strong contributors to each of the Student Outcomes.

Outcome a *(an ability to apply knowledge of mathematics, science, and engineering)* is achieved through the mathematics, science, and engineering topics content of the curriculum. Briefly, students are required to take three semesters of calculus (Math 221, 222, 234), one of differential equations (Math 319 or 320), one of statistics (Stat 324), two of physics (Physics 201 (mechanics), 202 (electricity and magnetism)), seven of chemistry, including General, Analytical, Organic, and Physical chemistry with laboratory components) and two of biology (Introductory Biology and Advanced Biology Elective). The 15 required chemical engineering courses, augmented by the students' elective series, provide the field-specific knowledge, in material balances, thermodynamic, kinetics and reactors, transport, materials, process control, and design.

Outcome b *(an ability to design and conduct experiments, as well as to analyze and interpret data)* is achieved in the broad selection of laboratory experiences developed in Chem 329, Phys 201/202, Chem 344, CBE 324, CBE 470, and CBE 424. A main purpose of these courses is to teach the students how to develop experimental methodologies in the context of the current course materials. A main component in the capstone laboratory course (CBE 424) involves students designing their own experiments from open-ended assignments. Analyzing and interpreting data is also a major emphasis in CBE 324, 424, and 470 laboratories. Analyzing and interpreting data also receives substantial attention throughout the chemical engineering curriculum, particularly in CBE 426 (Mass Transfer Operations) and CBE 430 (Kinetics and Reactor Design). Several of the supporting courses involve laboratory experiments and data interpretation. Finally, as an elective, many students participate in undergraduate research (CBE 489, 599, or 699). Working closely with faculty and graduate students in a research group, undergraduates gain experience in modern experiments, analysis, and interpretation.

Outcome c *(an ability to design a system, component, or process to meet desired needs)* is achieved mainly through the capstone Process Design course (CBE 450). The design course involves one or several major design projects, with attention to problem definition, consideration of alternatives, and production of a final design for evaluation. The capstone laboratory course, Operations and Process Laboratory (CBE 424), also requires

Table 5.2 Coverage of Student Outcomes in CBE Courses

(KEY: XX: emphasizes; X: addresses; V: variable; Blank: either only mentioned or not included)

CBE Program Outcomes → / Required Courses ↓	(a) an ability to apply knowledge of mathematics, science, and engineering	(b) an ability to design and conduct experiments, as well as to analyze and interpret data	(c) an ability to design a system, component, or process to meet desired needs within constraints	(d) an ability to function on multi-disciplinary teams	(e) an ability to identify, formulate, and solve engineering problems	(f) an understanding of professional, economic, environmental, and ethical responsibility	(g) an ability to communicate effectively	(h) the broad education necessary to understand the impact of engineering solutions in a global, environmental, economic, and societal context	(i) a recognition of the need for, and an ability to engage in life-long learning	(j) a knowledge of contemporary issues	(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	(l) program criterion, including process hazards
CBE 250 Process Synthesis	XX		X	X	XX	X	X	XX	X	X	XX	XX
CBE 255 Intro to Chemical Process Modeling	XX		X	X	XX	X	X	XX	X	X	XX	XX
CBE 310 Chemical Process Thermodynamics	XX				XX	X	X	X			XX	XX
CBE 311 Thermodynamics of Mixtures	XX	X			XX	X	X	X			XX	XX
CBE 320 Introductory Transport Phenomena	XX				XX	X	X	X			XX	XX
CBE 324 Transport Phenomena Lab	XX	XX		XX	XX	X	XX	X			XX	XX
CBE 326 Momentum and Heat Transfer Operations	XX		X		XX	X	X	X			XX	XX
CBE 424 Operations and Process Lab	XX	XX	XX	XX	XX	X	XX	X	X		XX	XX
CBE 426 Mass Transfer Operations	XX		X	X	XX	X	X	X	X		XX	XX
CBE 430 Chemical Kinetics and Reactor Design	XX	X	X		XX	X	X	X			XX	XX
CBE 450 Process Design	XX		XX	XX	XX	X	XX	XX	X	X	XX	XX
CBE 470 Process Dynamics and Control	XX	XX	X	X	XX	X	XX	X			XX	XX
One of CBE 440 Materials or CBE 540 Polymers or CBE 544 Electronic Mats. or CBE 547 Colloids	XX				XX	X	X	X	X	XX	XX	XX
CBE electives (all options)	XX	V	V	V	XX	X	X	X	X	X	XX	XX
CBE 599 Independent Study	V	V	V	V	X	V	V	V	XX	V	XX	XX

students to design and construct experimental setups for open-ended investigations. Smaller, multi-week design projects are contained in CBE 250 and CBE 426, and individual assignments in many other core courses involve aspects of process or product design.

Outcome d *(an ability to function on multi-disciplinary teams)* is achieved mainly through team projects in the laboratories (Chem 109, 329, 344, CBE 324, 424, and 470,), and through group design projects in CBE 250, 426, and 450. In each of these groups, students must work with others from different backgrounds (major, ethnicity, gender, and learning style), and must also organize to specialize and synthesize their expertise or component with the efforts of others in the group who have focused on other components. Students in early courses receive training in efficient teamwork, and their skills are encouraged and recognized in later courses. For example, in CBE 424 (Operations and Process Laboratory), the groups recognized as best displaying effective teamwork receive the Kowalke-Harr Award and accompanying cash prize.

Outcome e *(an ability to identify, formulate, and solve engineering problems)* is achieved through the engineering topics content of the curriculum. All 15 of the CBE courses have significant emphasis on identifying, formulating, and solving engineering problems, as is clear from the files of homework and exams. The core Unit Operations courses (CBE 326, 426, and 430) place particular emphasis on these skills.

Outcome f *(an understanding of professional and ethical responsibility)* is addressed throughout the core curriculum in the context of engineering problems and the consequences of decision-making on our local and global communities. The freshman engineering courses (often taken as Engineering Electives) include significant coverage. In addition, the Code of Ethics of the American Institute of Chemical Engineers is presented and discussed in both CBE 250 and 450.

Outcome g *(an ability to communicate effectively)* is addressed most directly through training and practice in written and oral communication in the laboratory courses, CBE 324, 424, and 470, and in the design course CBE 450. The University General Education requirement ensures that all students demonstrate basic and advanced writing skills, in a Communications A course as a freshman and a Communications B course as an upperclassman. Our CBE 424 laboratory has such significant writing and revision content that it received approval at the campus level as satisfying the Communications B requirement. Students write smaller reports or group reports in other core courses, and a major design report in CBE 450. Oral presentation training and opportunities are provided in several lower-level courses, and the required oral presentation in CBE 424 allows students to demonstrate their skill before graduation.

Outcome h *(the broad education necessary to understand the impact of engineering solutions in a global, environmental, economic, and societal context)* is addressed most directly in the Liberal Electives and the "design bookends," CBE 250 and 450, and to a moderate extent throughout the curriculum. The Liberal Electives are chosen to satisfy University General Education guidelines and departmental requirements, ensuring both breadth and depth of background outside engineering (see on-line curriculum guide at http://www.engr.wisc.edu/che/current/undergrad/curriculum/). The first and last design classes take great care to establish the societal needs for projects, and the underlying economic and environmental criteria necessary for successful solution. Most other courses consistently mention societal needs and the growing global scope of engineering problems.

Outcome i *(a recognition of the need for, and an ability to engage in life-long learning)* is addressed most directly in both CBE 250 and 424 in assignments that require students to find and use information from the library or other resources outside class. Training in use of general and specialized library resources is provided in class lessons planned and provided by the engineering librarian specializing in chemical engineering information. Most students also gain expertise in independent learning in the EPD 155 Communication A course, where a Computerized Library Use Education (CLUE) exercise uses web-based instruction to provide library research experience outside the classroom context. Most core engineering classes cover applications of chemical engineering fundamentals ranging from classical to state-of-the-art, and establish the pattern of understanding modern innovations in the context of similarities and differences relative to classical examples. In particular, the CBE 424 syllabus (http://www.engr.wisc.edu/che/courses/che424.html) and laboratory exercises relate modern applications to core concepts and establish that future problems will require extension of their existing background. Finally, most instructors explicitly expect our students to pursue additional training after graduation, whether in chemical engineering, business, or other fields.

Outcome j *(a knowledge of contemporary issues)* is addressed in a general, non-technical sense through the Liberal Electives, in the breadth and depth components, and through the interactions that students have with the larger community through their classmates and student organizations. Knowledge of contemporary technical issues is imparted by all instructors in core courses. Through modern examples and case studies, students acquire instances of chemical engineering applied to address current concerns. In particular, CBE 440 Engineering Materials and CBE 540 Polymer Science and Technology have a strong focus on current problems. Additionally, electives offer opportunities to explore current issues. The course CBE 555 Chemical Engineering Connections explores contemporary issues of chemical engineering interest. Other electives provide knowledge of current concerns in fields such as food, pharmaceuticals, biochemical engineering, and solar energy.

Outcome k *(an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice)* is addressed consistently throughout the engineering courses. The core thermodynamics and transport courses (CBE 310, 311, and 320) teach the fundamental chemical engineering sciences, and the unit operations courses (CBE 326, 426, 430, and 470) develop skill and particular techniques for solving engineering problems. These core courses start with analytical treatments for conceptual clarity and progress to numerical solutions of more complicated systems, using the same underlying modeling approach. Computational tools are used as appropriate throughout; spreadsheets (MS Excel) and equation solvers (MathCad or Engineering Equation Solver) are emphasized early, in CBE 250. Matlab is taught in depth in CBE 255 and used heavily in CBE 430 and 470. Process simulation software (ASPEN) is introduced in the thermodynamics (CBE 311) and mass transfer (CBE 426) courses, then used extensively for process design in CBE 450.

Outcome l *(ability to apply the basic sciences to the design, analysis, and control of chemical, physical, and biological processes, including the hazards associated with these processes)* is addressed by the breadth of topics included in the curriculum. The fundamental knowledge aspect is based on the core thermodynamics and transport courses (CBE 310, 311, and 320). The breadth component relies on the range of unit operations courses (CBE 326, 426, and 430). The depth aspect is satisfied by the specific electives chosen by each student, which permit them to focus on particular application areas within chemical engineering of most interest to them. As seen from Table 3.3B above, components of "chemical engineering processes" are provided in each of the courses in the curriculum. This coverage is described in greater detail below.

5.A.4 Flowchart of Program Prerequisite Structure

The College provides the EAGLE flowsheet to all engineering students as an advising tool to map their transcript record onto a one-page depiction of their degree requirements. This is a graphic tool to help students track completed courses and plan their remaining coursework across future semesters. An example of this one-page flowchart for a current student is included here as Figure 5.3 below. Note that it uses color coding to indicate completed requirements, planned courses, and coursework remaining to be scheduled. The prerequisite structure of our courses is indicated for clarity.

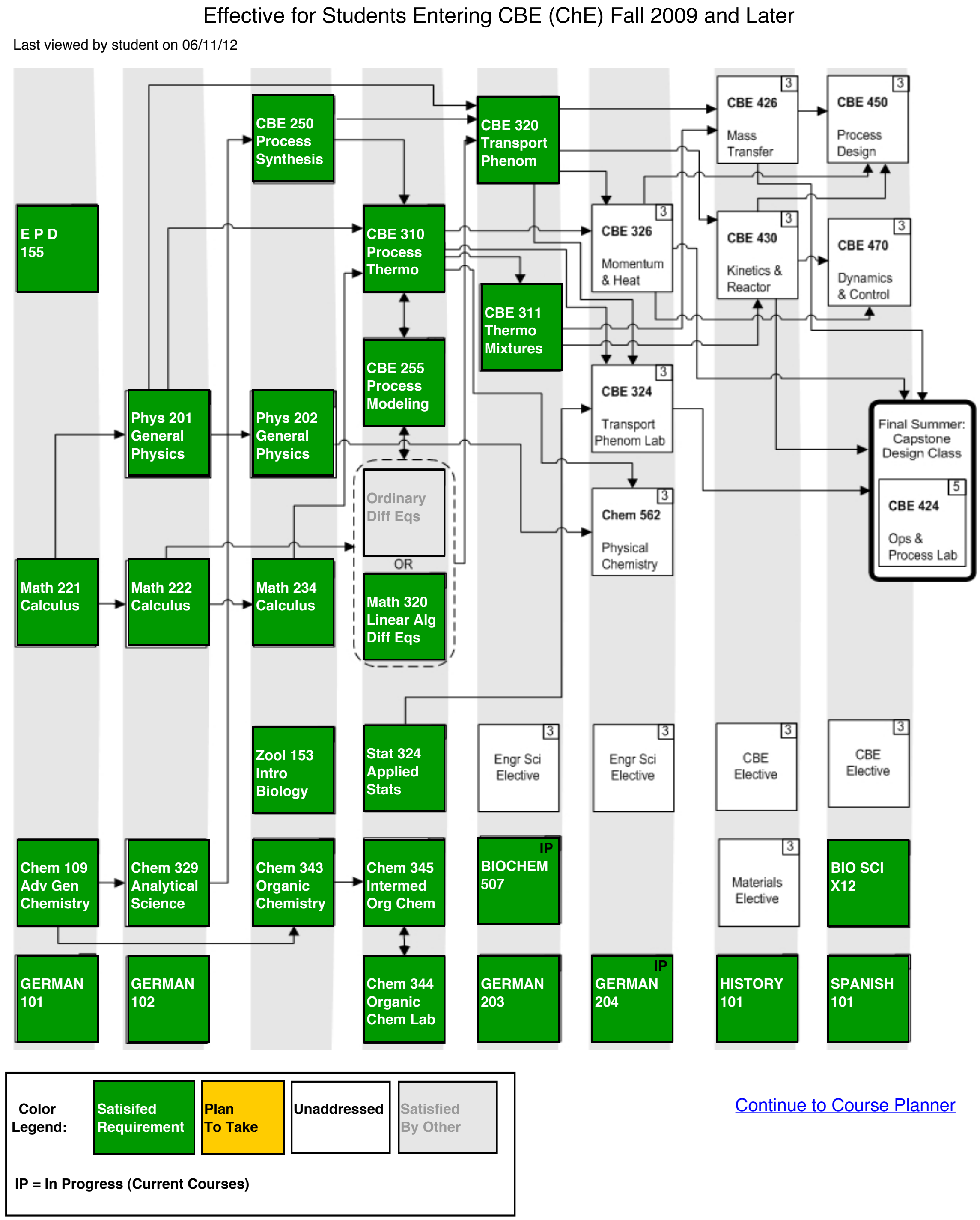
There are several key prerequisite chains through the program structure. The minimum time to complete the degree based on CBE courses is given by the 5-semester sequence of CBE 250 – 310 – 311 – 430 – 450. The CBE 424 capstone laboratory has as prerequisites all of CBE 326, 426, and 430, so it can be taken with one semester of CBE required courses remaining. Thus, we have large cohorts of students graduating in August after the Summer Lab and in December after a final semester of courses, and a small group of May graduates who have taken the Summer Lab the previous year.

As a one-page summary, the flowsheet omits some nuances of the elective sequences (Liberal Electives and Professional Breadth Elective). The Liberal Elective category is 16 credits total, with several sub-categories to satisfy UW General Education, College of Engineering, and Departmental requirements. The Professional Breadth Elective requirement is fulfilled by completing two courses chosen from Engineering courses, other technical courses, and a carefully selected list of non-technical courses from Business and other fields that have been approved for their relevance to student interests and career goals. These are all detailed in the Curriculum Guide, built into the DARS tool, and described below. Students understand that they are responsible for satisfying the more detailed Curriculum Guide or the complete DARS analysis.

The Advanced Biology Elective and Chemical Engineering Materials courses are Selected Electives, chosen from lists of four recommended alternatives. The Advanced Mathematics course is selected from two alternatives.

While the Communication A course (usually EPD 155) is not explicitly indicated as a prerequisite for any later course, students must complete this requirement prior to admission to the CBE major by the College EGR office.

Figure 5.3 – EAGLE Advising Flowchart for CBE Students



5.A.5 How Curriculum Meets General Criteria Requirements

The coursework listed chronologically in Table 5-1 can be organized by subject area to better understand how the curriculum builds to the desired overall experience.

5.A.5.1 Mathematics and Basic Science

Students in the Chemical Engineering Program are required to complete 51 credits of mathematics and basic science courses. Sixteen credits constitute a typical course load per semester, thus the mathematics and basic science requirements exceed the ABET-mandated one year of study. The courses that comprise the mathematics and basic science requirements are listed below in Table 5.4.

The courses listed in Table 5.4 provide essential underlying and enabling science and mathematics and also breadth in the fundamentals for all of our students. Two of the required physics courses (Phys 201 and Physics 202 and their equivalents) and the required Chemistry courses (Chem 109 and Chem 329) include a formal laboratory component.

Table 5.4: Courses for Mathematics and Basic Sciences Requirement

Mathematics Requirements, 19 cr

Math 221 Calculus and Analytic Geometry	5 cr
Math 222 Calculus and Analytic Geometry	5 cr
Math 234 Calculus -- Functions of Several Variables	3 cr
Math 319 Techniques in Ordinary Differential Equations or 320 Linear Algebra and Differential Equations	3 cr
Statistics 324 Introductory Applied Statistics for Engineers	3 cr

Science Requirements, 36 cr

A. Basic Science, 19 cr

Chem 109 General and Analytical Chemistry I	5 cr
Chem 329 Fundamentals of Analytical Science	4 cr
Physics 201 General Physics	5 cr
Physics 202 General Physics	5 cr

Transfer students whose general chemistry courses do not contain significant analytical chemistry content must take Chemistry 329 (or Chemistry 327). Credit shortages caused by transfer of freshman chemistry courses at fewer than 9 credits must be made up with chemistry, biochemistry or chemical engineering courses.

Transfer students who receive fewer than 6 credits for Physics 201/202 or 207/208 courses must make up the credit shortage with another physics course.

B. Advanced Chemistry Requirements, 11 cr

Chem 343 Introductory Organic Chemistry	3 cr
Chem 344 Introductory Organic Chemistry Lab	2 cr
Chem 345 Intermediate Organic Chemistry	3 cr
Chem 562 Physical Chemistry	3 cr

C. Life Science Requirements, 6 cr

Zool 153 Introductory Biology	3 cr
Advanced Biology Elective (Biochem 501, Genetics 466, Microbiology 303, Zool 570)	3 cr

5.A.5.2 Engineering Topics

Students in the Chemical Engineering Program are required to complete 48 credits of engineering topics courses. Sixteen credits constitute a typical course load, thus the engineering topics requirements specify one and one half years of study. The courses that comprise the engineering topics requirements are listed below in Table 5.5.

Table 5.5: Courses Comprising the Engineering Topics Requirement

CBE 250 Process Synthesis	3 cr
CBE 255 Introduction to Chemical Process Modeling	3 cr
CBE 310 Chemical Process Thermodynamics	3 cr
CBE 311 Thermodynamics of Mixtures	3 cr
CBE 320 Introductory Transport Phenomena	4 cr
CBE 324 Transport Phenomena Lab	3 cr
CBE 326 Momentum and Heat Transfer Operations	3 cr
CBE 424 Operations and Process Laboratory	5 cr
CBE 426 Mass Transfer Operations	3 cr
CBE 430 Chemical Kinetics and Reactor Design	3 cr
Chemical Engineering Materials	3 cr
CBE 440 Chemical Engineering Materials or	
CBE 540 Polymer Science and Technology or	
CBE 544 Processing of Electronic Materials or	
CBE 547 Introduction to Colloid and Interface Science	
CBE 450 Process Design	3 cr
CBE 470 Process Dynamics and Control	3 cr
CBE Electives	6 cr
Total	48 cr

Chemical engineering electives may be chosen from any of the chemical engineering courses that are not required, with the exception seminar courses. A maximum of two credits of co-op work (CBE 001) may be used to meet the CBE elective requirement. BSE 642, Food & Pharmaceutical Separations, can be taken as a CBE elective. Qualified undergraduates may take graduate-level (600 or 700) courses to fulfill this requirement. With a selection of several technical electives available in the curriculum and opportunities for independent study courses, students can develop expertise in areas of specific interest. Suggested sequences of elective courses are presented to the student in the undergraduate curriculum guide.

The program adds a *Professional Breadth Elective* requirement of 6 credits of coursework outside chemical engineering that is designed to provide additional exposure to topics of relevance to a student's career and professional goals. This requirement may be satisfied by any College of Engineering courses outside of chemical engineering numbered 300 or above, and many other courses in Chemistry, Biology, Physics, Math, Business, and related areas. Some students who are pursuing second majors or certificate programs use the Professional Breadth Elective to include some of these additional credits within their chemical engineering degree. Traditional choices for coursework includes ECE 376 – Electric Circuits and Electronics, ISyE 313 – Engineering

Economics Analysis, and polymer processing courses in Mechanical Engineering. While these courses may be common choices for students seeking conventional balance, many students select elective coursework from the broad range available with intent to customize their course of study. The department maintains a list of course categories and individual courses that have been approved and are automatically recognized by DARS for graduation certification. Students who have new course options they wish to take discuss this with their advisor and submit their request to the department. After approval, these courses are added to the master list.

Undergraduates are also encouraged to participate in research programs through independent-study courses. Indeed, many of our undergraduates do work with one or more of the graduate research groups, either for credit towards their chemical engineering electives, or for pay. Over the past six years, a yearly average of 29 students have registered for CBE 599 - Independent Study credits, with an average of 10 professors. This enrollment level is sufficient for more than 60% of our students to participate in independent study during their degree program, and some students participate in multiple projects. Feedback from our alumni survey indicated that independent study was a valuable component in the program. Almost half of the survey respondents had taken an independent study class, and, of these, 96% stated it was "valuable" or "somewhat valuable." One third of these students stated that the independent study course influenced their career. Thus, the research expertise of our faculty provides valuable enrichment experiences for our undergraduates.

5.A.5.3 General Education

All students at the University of Wisconsin – Madison must complete the UW General Education Requirements listed in Table 5.6. These are also described in detail at the following web site: http://studentservices.engr.wisc/edu/transfer/tips/sum_general.html (and in the undergraduate Catalog and elsewhere). Engineering students easily satisfy the Quantitative Reasoning and Natural Science Requirements. The Communication Part A requirement has been incorporated into the Chemical Engineering program requirements in the form of EPD 155 (or other approved Communications Part A option courses). The Communication Part B requirement is satisfied by the senior laboratory course, CBE 424. This laboratory course has extensive writing and rewriting involved, and has been certified at the university level as meeting the requirement. Students have flexibility in satisfying the Liberal Electives Requirement (http://studentservices.engr.wisc.edu/transfer/tips/sum_liberal.html). College rules require that students obtain both breadth and depth via their liberal electives.

Students have flexibility in satisfying the UW Liberal Electives Requirement by selecting courses from approved lists. The College of Engineering requires that students obtain not only the breadth required by the University in satisfying the liberal studies requirements (humanities, social studies and ethnic studies), but also depth in one field of the liberal studies, achieved by taking two courses in the same department, one of which is at the intermediate or advanced level. The purpose of the liberal studies requirement is to ensure that every engineering student will have significant exposure to the humanities and social sciences. The underlying values of the breadth requirement reflect the belief that all educated persons share some common knowledge across the range of human scholarly endeavors. Breadth also refers to the standard that a college education must

Table 5.6 General Education Requirements

The UW requires all graduates to have completed:

Communication, 4-6 credits

> Part A: Literacy Proficiency. 2-3 credits at first-year level dedicated to reading, listening, and discussion, with emphasis on writing. Students may be exempted from Part A by high school course work or testing. Part B: Enhancing Literacy Proficiency. 2-3 credits of more advanced course work for students who have completed or been exempted from Part A

Quantitative Reasoning, 3 to 6 credits

> Part A: 3 credits of mathematics, statistics, or formal logic. Students may be exempted from Part A by approved college coursework while in high school or by testing. Part B: 3 additional credits in quantitative reasoning.

Natural Science, 4 to 6 credits

> One 4- or 5-credit course with a laboratory component; or two courses providing a total of 6 credits.

Humanities/Literature/Arts, 6 credits*.

Social Studies, 3 credits*.

Ethnic Studies, 3 credits*.

* The College of Engineering requires a total of 16 credits of Social Studies, Humanities/Literature/Arts and Ethnic studies, and depth in one area within these electives, specifically two courses from the same department, one of which is at the intermediate or advanced level.

combine specialization in one discipline with general awareness of content, aims, and methods of those other principal fields. These area and level designations are assigned at the campus level by faculty from the relevant departments. We rely on their assessment and feedback to maintain the excellence of these courses, and they have received high praise from their accrediting body (North Central Association of Colleges and Schools) in the recent 2009 visit.

5.A.6 Description of Major Design Experience

The curriculum provides students with multiple opportunities to practice chemical engineering skills within realistic constraints.

Feedback from employers and senior industry representatives on the Visiting Committee and College Industrial Advisory Board repeatedly emphasizes the desirability of integration of design at multiple stages of the curriculum rather than relying solely on a single capstone course. Design experiences are woven throughout the chemical engineering curriculum. Most students get their first exposure to a group design project in the sophomore introductory course, CBE 250. Design at this stage is necessarily focused on elementary ‘big picture’ issues such as process chemistry choices, flowsheet sequencing, and overall mass and energy balances. Even at this early point, students learn to consider safety, environmental and economic consequences of process decisions. Several subsequent courses incorporate a design component into the syllabi. CBE 426 (Mass Transfer Operations) is an outstanding example of a course in which students use their growing knowledge of unit operations and modeling strategies in the detailed design of a separation process.

The design sequence culminates in the **semester-long design project** of CBE 450 - Process Design. This course provides an introduction to *rigorous process design*, to be distinguished from equipment design, or process analysis at a simplified level. Students learn specific design strategies in reactor network analysis, separation selection and sequencing, and energy integration. Students experience the challenges of *solving a complex engineering design problem*. Each semester the instructor selects a different design problem for the design groups to address. Some projects are modern updates of classic problems based on industrial descriptions, such as AIChE Student Design Competition problems like methanol plants. Others are based on recent innovations and alternative technologies, such as a biofuels plant based on a technology from a recent patent application out of a research group in the department.

In these extensive projects, students learn to consider process hazards, environmental regulations, and economic evaluations at multiple stages throughout the design process. They gain an appreciation for how different components of a process interact, and that the globally optimized process may not be locally optimized. This experience requires that a large palette of the specific subjects studied in earlier courses be applied in concert, where issues in reactors, separations, and resource utilization must be considered simultaneously. Although the major emphasis is placed on process design, students also gain significant experience in equipment design, capital cost estimating, and profitability analysis. This experience provides practice that solidifies competence in the specific subjects, while helping to develop a perspective on the role these subjects play in the practice of engineering. Further, students discover that answers to process design questions are not facts to be learned *a priori*, but instead must be determined for each case. They learn that the methods of chemical engineering analysis, mastered in prior courses, enable them to arrive at appropriate but not necessarily unique answers. Class activities bolster elements of professionalism: the responsibility of the individual for the quality and correctness of engineering reports, the obligation to provide needed results within the required time frame, effective functioning as a member of a project team, and adherence to professional standards and conventions for representing and transmitting engineering information. The senior capstone course seeks to promote creativity in solving open-ended design problems, and provide practice in critical thinking and written and oral communication skills, incorporating appropriate engineering standards and multiple design constraints.

An additional facet of UW-Madison's chemical engineering program is an intensive five-week unit capstone operations laboratory course for seniors. CBE 424 – Operations and Process Laboratory, is usually taken in the student's last summer. This required laboratory experience allows students to use equipment similar to that found in industrial chemical plants to solve problems resembling those they will encounter throughout their careers. In addition to the five formal experiments on pilot-plant scale equipment, all student teams must conduct four informal (unstructured) experiments that require them to research a topic, design and construct equipment, design and conduct experiments, and finally draw conclusions and communicate them through oral or written reports. CBE 424 is a capstone laboratory course that draws together and integrates most of the engineering concepts and technical abilities that students have been learning throughout the curriculum. Although our students perceive this course as very difficult, it draws widespread acclaim from our alumni and employers in all of the feedback mechanisms we have used. The summer lab experience has aptly been described as "chemical engineering boot camp" !

5.A.7 Cooperative Education

Engineering Career Services (ECS) administers and evaluates the Cooperative Education Program, through which engineering students receive technical elective credits toward their degrees. CBE students are permitted to count up to 2 credits of CBE 001 – Cooperative Education towards their Chemical Engineering Elective requirement. These industrial experiences are typically arranged with employers through ECS and must conform to their program expectations. The ECS office ensures that students work at least 40 hours a week for a minimum of 15 weeks during fall or spring or a minimum of 12 weeks during the summer. All supervisors for co-op students are required to have at a minimum a Bachelor of Science degree in engineering, and the supervisor's feedback on student performance is critical to the ECS evaluation process.

The cooperative education course grade is awarded based on the reflection component of the cooperative education assignment. After completing the work on site, students participate in a discussion or fulfill a written requirement. Through these experiences students are asked to reflect on what they have observed and experienced in their daily environment and provide information on how this will shape their actions, attitudes, and approaches in the future. They are asked to address questions about the work that they were assigned, providing specific examples of situations that challenged their existing skill set; they then provide details about how they worked through problems and how they communicated about challenges with supervisors. They reflect on the learning that happened in the cooperative experience, especially any learning that they could not or did not gain in formal courses in their major; they also discuss communication skills they developed through conducting their job search and working with their supervisors. If their co-op experience educated them about emerging opportunities within their field, they are asked to share those.

Both a supervisor and a student evaluation are considered in evaluating student participation and granting credit in the program. The ECS office responds to any negative feedback from either supervisors or students by meeting with the students involved and ensuring that the co-op experience is a positive learning opportunity. The vast majority of students do very well in their co-operative education, at least meeting and in many cases exceeding expectations. Beyond this evaluative process, the student and supervisor feedback is also captured in survey form and provided to engineering programs as part of their continuous improvement process. Use of this feedback in CBE program assessment as a direct measure from outside sources is described above in the Criterion 4 discussion.

5.A.8 Materials for Review at Visit

Supporting materials to document detailed content of the curriculum will be collected and available for review during the site visit. Physical items such as textbooks will be present in the department conference room where the review is based. Samples of student work from many Spring 2012 courses will display performance at high, medium, and low levels These have been scanned and stored; these electronic resources will be on the department assessment web server and accessible from a computer in that same room. Student reports at different stages of design projects will be included. Standard ABET syllabi are presented in Appendix A of this document. Other material of interest may be arranged by request.

5.B Course Syllabi

Appendix A contains the standard ABET-format syllabi for required and selected-elective CBE courses, and also standardized syllabi for the required and selected-elective mathematics and science courses.

CRITERION 6 – FACULTY

6.A Faculty Qualifications

The Chemical and Biological Engineering Department has 19 tenured or tenure-track faculty, one non-tenure track faculty associate, one academic staff instructional lab manager, and one affiliate faculty from another college. All teaching faculty have Ph.D. degrees in Chemical Engineering or related, relevant fields. Details of educational backgrounds and experience are shown in Table 6 - 1: Faculty Qualifications. Summarizing professional society membership and review activities indicating high standing in individual fields, we collect the following statistics:

AIChE members –13
ACS members –9
APS members –5
Membership on journal editorial boards – at least 17 journals
NIH study section members – 3
Members of NAE or AAAS - 3

All faculty participate in appropriate proportions in undergraduate teaching activities and in graduate and/or undergraduate research. The full-time CBE faculty has the competencies to cover all program curricular areas.

CBE Faculty Expertise: Research and Teaching Interests
Categorized in Terms of CBE Core Teaching Areas

Applied Mathematics
J. J. dePablo
M. D. Graham
D. J. Klingenberg
C. T. Maravelias
M. Mavrikakis
J. Reed
R. E. Swaney

Biotechnology
N. L. Abbott
J. J. dePablo
M. D. Graham
D. M. Lynn
R. M. Murphy
P. F. Nealey
S. P. Palecek
B. F. Pfleger
J. Reed
E. V. Shusta
J. Yin

Colloids/Particle Technology
N. L. Abbott
C. G. Hill, Jr.
D. J. Klingenberg
J. B. Rawlings

Kinetics and Catalysis
J. A. Dumesic
M. Mavrikakis
J. B. Rawlings
J. Reed
T. W. Root

Materials
N. L. Abbott
J. J. dePablo
T. F. Kuech
D. M. Lynn
M. Mavrikakis
P. F. Nealey
T. W. Root

Polymers and Rheology
J. J. dePablo
M. D. Graham
D. J. Klingenberg
D. M. Lynn
P. F. Nealey

Process Control & Design
C. T. Maravelias
R. M. Murphy
J. B. Rawlings
R. E. Swaney
J. Yin

Thermodynamics
N. L. Abbott
J. J. dePablo
B. F. Pfleger
R. E. Swaney

Transport Phenomena
M. D. Graham
D. J. Klingenberg
J. Yin

Table 6-1. Faculty Qualifications

Department of Chemical Engineering, UW-Madison

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment [2] T, TT, NTT	FT or PT [3]	Years of Experience			Professional Registration/ Certification	Level of Activity [4] H, M, or L		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Nicholas L. Abbott	PhD Chemical Engineering 1991	P	T	FT	0	21	15		M	M	M
Rafael Chávez-Contreras	PhD Chemical Engineering 198x	I	NTT	FT	1	36	12		L	L	L
Eric Codner	PhD Chemistry 2001	I	NTT	FT	4	7	6		L	L	M
Juan J. de Pablo	PhD Chemical Engineering 1990	P	T	FT	2	20	20		H	L	M
James A. Dumesic	PhD Chemical Engineering 1974	P	T	FT	2	36	36		H	M	M
Mark Etzel	PhD Chemical Engineering 1983	P	T	FT	6	23	23		M	M	H
Michael D. Graham	PhD Chemical Engineering 1992	P	T	FT	0	18	18		H	M	L
Daniel J. Klingenberg	PhD Chemical Engineering 1991	P	T	FT	0	20	20		H	M	M
Thomas F. Kuech	PhD Applied Physics 1981	P	T	FT	9	22	22		H	M	L
David M. Lynn	PhD Chemistry 2002	P	T	FT	0	10	10		M	M	L
Christos Maravelias	PhD Chemical Engineering 2004	ASC	T	FT	0	8	8		M	L	L
Emmanouil Mavrikakis	PhD Chemical Engineering 1994	P	T	FT	3	13	13		H	M	M

Faculty Name	Highest Degree Earned- Field and Year	Rank [1]	Type of Academic Appointment [2] T, TT, NTT	FT or PT [3]	Years of Experience			Professional Registration/ Certification	Level of Activity [4] H, M, or L		
					Govt./Ind. Practice	Teaching	This Institution		Professional Organizations	Professional Development	Consulting/summer work in industry
Regina M. Murphy	PhD Chemical Engineering 1989	P	T	FT	5	23	23		M	M	L
Paul F. Nealey	PhD Chemical Engineering 1994	P	T	FT	4	16	16		H	M	M
Sean P. Palecek	PhD Chemical Engineering 1998	P	T	FT	0	12	12		M	M	L
Brian F. Pfleger	PhD Chemical Engineering 2005	AST	TT	FT	0	6	6		L	L	L
James B. Rawlings	PhD Chemical Engineering 1985	P	T	FT	0	22	17		H	H	H
Jennifer R. Reed	PhD Chemical Engineering 200x	AST	TT	FT	0	7	5		L	L	L
Thatcher W. Root	PhD Chemical Engineering 1984	P	T	FT	2	26	26		L	M	L
Eric V. Shusta	PhD Chemical Engineering 2001	ASC	T	FT	0	11	11		M	M	L
Ross E. Swaney	PhD Chemical Engineering 1983	ASC	T	FT	4	27	27		L	M	L
John Yin	PhD Chemical Engineering 1988	P	T	FT	0	20	14		M	M	L

Instructions: Complete table for each member of the faculty in the program. Add additional rows or use additional sheets if necessary. Updated information is to be provided at the time of the visit.

1. Code: P = Professor ASC = Associate Professor AST = Assistant Professor I = Instructor A = Adjunct O = Other
2. Code: T = Tenured TT = Tenure Track NTT = Non Tenure Track
3. Code: FT = Full-time PT = Part-time Appointment at the institution.
4. The level of activity (high, medium or low) should reflect an average over the year prior to the visit plus the two previous years.

Collectively, our faculty has the competencies to cover all of the curricular areas of the program. Most faculty regularly teach in rotation several core undergraduate courses, in addition to senior electives (or graduate topics that may also be used as electives). Typically there are three or four faculty who actively teach each of the core courses. The Department Chair maintains a matrix indicating what faculty are active teaching which core courses, and uses this to identify areas of need when developing new teaching assignments for junior faculty or for senior faculty ready to rotate to new teaching assignments. Since most of our faculty members have undergraduate and graduate training in Chemical Engineering, it is generally accepted that they could teach any of the core undergraduate courses. Three of our faculty members have significant industrial employment experience, and many others collaborate or consult with industry, so there is also substantial background experience to tie our undergraduate course material to real-life applications. Most faculty had postdoctoral positions to broaden their range of experience before entering their academic careers. The few faculty members whose degrees are not in Chemical Engineering typically specialize in a smaller subset of courses that overlap with their expertise. The number of these cases does not significantly constrain planning the teaching schedule.

Curriculum Vitae with more detail on training, experience, accomplishments, and recognition for all faculty members are provided in Appendix B.

6.B Faculty Workload

Table 6-2, Faculty Workload Summary, is included below.

A full-time faculty member in the Chemical Engineering program is expected to teach two courses per year if he/she has a very strong research program supporting a significant number of undergraduate and graduate students. Center directors and others with unusually large administrative responsibilities or research activity may “buy out” of teaching responsibilities and reduce this load, while providing resources for the department to arrange course coverage by visiting professors on sabattical, or other qualified guest instructors. The teaching load increases to four or more courses or equivalent service duties per year if a faculty member has a minimal research program. Teaching a new course for the first time generally results in a reduced course load that semester. A typical faculty member in the program will teach one undergraduate and one senior or graduate-level course per year. This load is in addition to average service on departmental, college or university level committees. Untenured faculty are assigned reduced loads of one course per semester while developing their core course repertoire in the early years of their appointment. The summer teaching schedule is managed separate from the academic year assignments.

Table 6-2. Faculty Workload Summary

Chemical Engineering Program

Faculty Member (name)	PT or FT[1]	Classes Taught (Course No./Credit Hrs.) Term and Year[2]	Program Activity Distribution[3]			% of Time Devoted to the Program[5]
			Teaching	Research or Scholarship	Other[4]	
Nicholas L. Abbott	FT	CBE 547/3 cr. S'12	30	50	20	100
Rafael Chávez-Contreras	FT	CBE 311/3 cr. F'11, CBE 326/3 cr. F'11 CBE 326/3 cr. S'12, CBE 426/3 cr. S'12	90	0	10	100
Eric Codner	FT	CBE 324/3 cr. F'11 CBE 324/3 cr. S'12, CBE 575/3 cr. S'12	50	0	50	100
Juan J. de Pablo	FT	CBE 710/3 cr. F'11 research leave S'12	30	50	20	100
James A. Dumesic	FT	sabbatical	0	50	50	100
Mark Etzel	FT	Food Sci 642/3 cr. S'12	40	50	10	0
Michael D. Graham	FT	CBE 720/3 cr. F'11 CBE 620/3 cr. S'12	40	50	10	100
Daniel J. Klingenberg	FT	CBE 320/4 cr. F'11, CBE 562/3 cr. F'11 InterEgr 102/2 cr. F'11 CBE 320/4 cr. S'12, CBE 562/3 cr. S'12 InterEgr 102/2 cr. S'12	40	50	10	100
Thomas F. Kuech	FT	research leave F'11 CBE 440/3 cr. S'12	40	50	10	100
David M. Lynn	FT	CBE 250/3 cr. F'11 CBE 540/3 cr. S'12	40	50	10	100
Christos Maravelias	FT	sabbatical	0	50	50	100

Emmanouil Mavrikakis	FT	CBE 735/3 cr. F'11 CBE 310/3 cr. S'12	30	50	20	100
Regina M. Murphy	FT	CBE 450/3 cr. F'11 CBE 311/3 cr. S'12	40	40	20	100
Paul F. Nealey	FT	CBE 540/3 cr. F'11 research leave S'12	30	50	20	100
Sean P. Palecek	FT	CBE 250/3 cr. F'11 CBE 562/3 cr. S'12	30	50	20	100
Brian F. Pfleger	FT	CBE 560/3 cr. F'11 research leave S'12	40	50	10	100
James B. Rawlings	FT	CBE 660/3 cr. F'11 CBE 470/3 cr. S'12	35	50	15	100
Jennifer R. Reed	FT	CBE 255/3 cr. F'11 CBE 430/3 cr. S'12	40	50	10	100
Thatcher W. Root	FT	CBE 430/3 cr. F'11, CBE 555/1 cr. F'11, InterEgr 160/3 cr. F'11 CBE 250/3 cr. S'12, CBE 555/1 cr. S'12, InterEgr 160/3 cr. S'12	40	30	30	100
Eric V. Shusta	FT	CBE 426/3 cr. F'11 CBE 783/3 cr. S'12	40	50	10	100
Ross E. Swaney	FT	CBE 310/3 cr. F'11, CBE 470/3 cr. F'11 CBE 255/3 cr. S'12, CBE 450/3 cr. S'12	60	30	10	100
John Yin	FT	research leave	0	50	50	100

1. FT = Full Time Faculty or PT = Part Time Faculty, at the institution
2. For the academic year for which the self-study is being prepared.
3. Program activity distribution should be in percent of effort in the program and should total 100%.
4. Indicate sabbatical leave, etc., under "Other."
5. Out of the total time employed at the institution.

6.C Faculty Size

6.C.1 Adequacy for Instructional Duties

During the 2011-12 academic year, the CBE program faculty consisted of 19 full-time faculty of various rank; a full time faculty associate instructor (Dr. Rafael Chávez); and the undergraduate lab director (Dr. Eric Codner) who also participates part-time in instruction. All core courses are taught by these faculty. Recitations may be led by teaching assistants or occasionally by faculty too. This size has been sufficient for the department to offer all core courses and most selected electives every semester. This department policy permits operation with moderate class sizes compared to teaching required courses only once per year, and allows co-op students to resume study without delay on return from their semester off campus. However, this extensive use of faculty teaching core courses does constrain the capacity for providing the broad range of senior elective courses that the faculty would like to teach.

Our faculty size of 19 full-time faculty members and two academic staff is adequate but not ideal for the size of our educational program. The department has been at approximately 20 full-time faculty equivalents (FTE) for much of the last two decades and has found that level to allow for balanced distribution of the many tasks expected of our faculty. Faculty hiring has been and continues to be a top priority as the department strives to build back to 20-22 FTE to maintain and add to our strengths in instruction and research. The biological sciences have been a focus of hiring over the past ten years. We will continue to maintain the faculty numbers and areas of expertise critical to our undergraduate program. In the last six years, we have had one faculty retirement and have hired two new assistant professors. One new mid-career hire is scheduled to arrive by fall 2012.

6.C.2 Faculty Involvement in Interactions with Students

Interactions between the faculty and students in the CBE department are extensive, professional, and of high quality. Venues for faculty-student interactions include classroom instruction, discussion sections and office hours, student advising, faculty-lead research programs, student organizations, and social activities.

Classroom instruction: Required courses are taught by faculty in sections of 40-55 students, providing opportunities for direct interaction on a more individual basis than students experienced in large, freshman lectures for math and chemistry courses.

Advising: Most of the full time faculty members serve as academic advisors for department students. Their role is to provide curricular and career advice on a regular (at least once a semester) basis. Most advisors interact with their advisees more regularly, both formally and informally. Each student is generally advised by the same advisor throughout their enrollment in the department in order to establish deeper relationship between the student and the advisor. Students may choose their advisor, as discussed in Criterion 1.

AIChE: Many of the CBE students are active in the student chapter of the American Institute for Chemical Engineering (AICHE). Professor Jennifer Reed serves as faculty advisor for the student organization. They generally meet monthly and provide a forum for student networking, interaction with industrial visitors, and student-centers competition, such as the Chem-Car contest of the AICHE.

Undergraduate research: Many students participate in research projects with faculty and graduate students through CBE 59 – Independent Study or CBE 489 – Honors Research. These interactions allow students to work with a mentor on a research project of current interest for one or more semesters. They learn how to plan projects, work on teams and independently, and gain appreciation of how their chemical engineering background has prepared them for extending into new topics or applications.

Social activities: Students and faculty socialize at department picnics, receptions for scholarship recipients and donors, and other occasions. The department and the AIChE student chapter co-sponsor graduation receptions for families of graduating seniors each May and December. For example, the May 2012 reception was attended by 42 May and August graduates, 150 family members, 5 faculty, and several department staff.

6.C.3 University Service

In the UW spirit of faculty governance, faculty have service roles all across the university including representing the department in the Faculty Senate, on the Physical Sciences Committee, and on the College's Academic Planning Council as well as participation in a multitude of university and college committees. Among the latter, at present department faculty sit on the Athletic Board, the Committee on Faculty Rights and Responsibilities, the Conflict of Interest Committee, and the COE Dean Search Committee (chair and one member).

6.C.4 Professional Development

Professional development of faculty is achieved mostly via their participation in research, in professional societies, and in professional meetings. Most faculty members are active members of AIChE and several additional societies with more specialized interests, as can be seen from faculty resumes. All faculty members are expected to publish in archival, peer-reviewed journals. This expectation ensures that they remain current in their field of expertise and that their intellectual work will pass review by colleagues in their respective fields. This professional development is funded largely by research grants and contracts sponsored by government and industry. In addition, the Department and College fund professional development activities related to instructional and assessment purposes through on-campus workshops and travel to off-campus conferences and workshops.

6.C.5 Interactions with Practitioners

Faculty interact with industrial and professional practitioners who are potential employers of students directly in conversations with recruiters, and also through numerous research collaborations with public and private industry and involvement with professional societies. In addition, several faculty have developed local start-up companies. The faculty promote the Wisconsin Idea by providing an ongoing service to the College, the University, the State, and well beyond the boundaries of the State.

6.D Professional Development

Faculty in the program have a number of funding opportunities for professional development, including system-wide faculty development grants, sabbaticals, Madison Initiative for Undergraduate grants, and College of Engineering funded grants for pedagogical innovation. In addition, there are opportunities both on and off campus through which faculty can develop their teaching and maintain their professional connections with industry and research. These opportunities are detailed below.

6.D.1 Formal Professional Development Funding Opportunities

<u>UW System Faculty Development Grants</u>

The faculty development program offered through the University of Wisconsin System is dedicated to the maintenance of academic excellence; thus, the System dedicates available funds to support effective and comprehensive faculty retraining, renewal, and development. The financial objective behind the program is to minimize the fiscal implications to the participant. Funding for retraining and renewal of faculty aims to develop expertise that will help units adapt to changing curricular, student, and societal needs; professional growth of faculty may also be supported where special needs are identified for improvement of teaching techniques or skills or development of the curriculum, particularly where service learning components can be integrated into the curriculum. More information on these grant programs is available through the UW-Madison campus Office of Human Resources.

<u>Faculty Sabbatical Funding</u>

Sabbaticals enable faculty members to engage in intensive study in order to become more effective teachers and scholars and to enhance their services to the University. Sabbatical leave may be granted for the purpose of enhancing teaching, course and curriculum development, or conducting research or any other scholarly activities related to **instructional** programs within the field of expertise of the faculty member. To be eligible, the faculty member must be an instructor, assistant professor, associate professor or professor in any UW-Madison school/college or department; and have completed six or more years of full-time instructional service, or the equivalent, at the University of Wisconsin. Preference is given to those making significant contributions to teaching, and to those who have not taken a leave of absence, regardless of the funding source, in the four years previous to application for sabbatical. Plans available allow for either a semester at any level up to full salary or a year at any level up to 65% of salary. Salary compensation may vary from college to college.

<u>Madison Initiative for Undergraduates</u>

Since 2010, UW-Madison campus has been using part of their supplemental tuition funding to encourage innovations in pedagogy; faculty are encouraged to submit proposals that will improve quality of the learning experience and better access to undergraduate courses. Interdisciplinary projects like the expansion of the freshman level Society's Engineering Grand Challenges course have been funded recently; this course brings together program faculty with a wide range of other engineering faculty and a variety of first-year students both in and outside of engineering.

College of Engineering Funding for Innovative Pedagogy

Criterion 1 describes the local funding available through the College of Engineering dean's office for faculty and staff interested in developing innovative pedagogy; before the year 2010, these grants were known as the Engineer of 2010 grants; since 2010, they have been renamed Engineering Beyond Boundaries (EBB) grants, and in 2011, they become EB^2 grants. Several COE faculty have been involved with successful projects since the inception of this grant program in 2007.

6.D.2 On-Campus Teaching and Professional Development Opportunities

College of Engineering Teaching Improvement Program

Formal teaching workshops for new and continuing faculty are provided at the beginning of the semester in both Fall and Spring; they are administered through Wendt Commons and funded by the College of Engineering. All new and continuing faculty and staff are encouraged to attend the Teaching Improvement Program (TIP), which typically involves two to three days of workshops on innovative teaching methods and technology-enhanced learning initiatives; some nuts-and-bolts workshops are provided on creating course websites and grading, other workshops focus on teaching special topics like engineering ethics or technical presentations.

Workshops on Improving Communication in Senior Design

As part of an ongoing, College-wide effort initiated by the Technical Communication Program, senior design professors in all departments have been invited to attend regular workshops focused on sharing problems in undergraduate engineering writing and working toward a more consistent pedagogy across the College for communication. The senior design faculty have regularly participated in these workshops since they began in 2009, and the workshops themselves have inspired several ongoing collaborative relationships between senior design and Technical Communication.

UW-Madison Teaching Academy

This campus-wide organization holds an annual Teaching and Learning Symposium through which faculty across the campus share innovative teaching practices; faculty can also apply for funding to attend the Teaching Academy Summer Institute, a week-long workshop for designing and improving courses or developing teaching skills. The website for the Teaching Academy provides information on numerous teaching improvement programs available on campus – including the Delta Program (a research, teaching, and learning community for faculty, staff, and post-docs in the STEM disciplines) and the Center for the Integration of Research, Teaching, and Learning (CIRTL) Diversity Institute, which aims to reform graduate training and faculty practice in STEM disciplines. Information about teaching workshops and awards can also be found at the Teaching Academy website, https://tle.wisc.edu/teaching-academy

Teaching Opportunities through the International Engineering Study Abroad Program

Programs have been developed through the College of Engineering International Studies and Programs Office that allow our faculty to teach courses overseas, developing their understanding of global challenges for engineering while deepening their knowledge of other cultures and languages: Faculty and staff have taught study abroad engineering courses in Toulouse, France (2006) and more recently in Hangzhou, China (2008-2012). A new initiative that is being developed for summer 2012 is a collaborative teaching/study abroad experience in Grimstad, Norway.

6.D.3 Off-Campus Faculty Professional Development Activities

In addition to the formal university professional programs described above, there are many other venues for professional development. The following list describes some of the many ways in which faculty develop and communicate their expertise. **See Appendix B,** Faculty Vitae for a detailed description of the professional development activities of each faculty member.

- Professional society activity: Virtually all faculty participate heavily in their professional societies. Their contributions include presentations at conferences, publications in journals chapters in books, invited and keynote lectures. Additionally, they serve program, administration, honors, research, editorial, review, or other committees within their professional societies
- Leaves of absence: faculty are permitted to obtain a leave of absence to work in an industry, a university, or a government laboratory for up to a year.
- Instruction: faculty give seminars and short courses in the Engineering Professional Development department, at other universities, or in industry.
- Consulting in industry: university rules permit faculty to consult for up to one day a week, and many faculty provide technical advice to companies in their areas of expertise
- Expert witnesses for companies: faculty are often sought out to provide expert opinions in industrial patent cases and other matters.
- Industrial advisory boards: faculty members participate on the research and development boards of industries in their areas of interest

6.D.4 Professional Development Activities for Instructional Academic Staff

Professional development opportunities for these instructors can be much more limited than those available to tenure track faculty; for example, instructional staff are not typically given sabbaticals. However, UW Campus Professional Development Grants are an option for these instructors, as are the Engineering Beyond Boundaries grants and the Madison Initiative for Undergraduate grants. The department has discretionary funds that can support the professional development activities of instructors. For example, Dr. Codner attended the November2011 AIChE Annual Meeting and presented a talk on lab innovations in a session on undergraduate laboratory improvements. Instructional staff do consulting work in industry, write or participate on major grants, and contribute to both the Teaching Academy and all of the COE teaching development programs listed above.

6.E Authority and Responsibility of Faculty

Shared governance is a fundamental component of the University of Wisconsin, established by state statute. Shared governance means that Faculty and Academic Staff members, through their representatives, shall actively participate in the governance and policy development of the institution, and have representation in matters that affect them. These rights are established through the Wisconsin State Statutes Chapter 36, available at the Secretary of the Faculty website, www.uwex.edu/secretary/. Faculty are defined as all persons who hold the rank of professor, associate professor, assistant professor, or instructor with at least a one-half time appointment. A department consists of a group of faculty members recognized by the faculty, chancellor, and the Board of Regents as dealing with a common field of knowledge.

The UW-Madison Faculty Policies and Procedures Manual (FPPM) documents in detail the authority and responsibility of the faculty, the departmental executive committee, and the department chair. Thus the responsibility for evaluation, assessment, and continuing improvement in the program is diffuse; it is the purview of the faculty and the various departmental committees on which they serve, though department chairs, deans, and the provost frequently engage with and support these activities. Below are direct quotes from the Faculty Policies and Procedures Manual attesting to the power of the faculty within departments:

> The immediate governance of the department is vested in its departmental faculty, which has jurisdiction over all the interests of the department, including authority to determine all departmental questions that are not vested in the departmental executive committee. The faculty of the department shall be responsible for teaching, research, and public service.
>
> The departmental executive committee has authority to make recommendations concerning faculty appointments, recruitment, leaves, nonretentions, dismissals, promotions, and salaries and other departmental budget matters, which are transmitted through the chair to the dean.
>
> The department chair has many leadership duties, among them the following:
>
> - Determines that all necessary records of teaching, research and public service of the department are properly kept and are always accessible to the proper authorities.
> - Reports to the dean regarding the activities and needs of the department.
> - Has responsibility for all departmental supplies.
> - Submits new courses, major revisions of existing courses, and deletion of courses proposed by the department for action by the divisional executive committee and by the dean. (UW-Madison Faculty Policies and Procedures, Chapter 5.

The Department Chair is appointed by the Dean based on an annual advisory vote of the department. The Department of Chemical and Biological Engineering has a standard term of 3 years for Chair in the current era. The Chair appoints Associate Chairs for Undergraduate and Graduate programs, as well as determining the membership of the many department committees (as provided in Background section). Most significant for this review are the Curriculum Committee and the Assessment Committee.

Each department selects a representative for the College Academic Policy, Curriculum, and Regulations Committee (APCRC), which has authority over course changes, new courses, course substitutions, and small-scale curriculum changes; each department also sends a representative to the Academic Planning Council (APC), which reviews large-scale budgetary or curriculum changes in the College and new degree or certificate programs.[1]

[1] Both the APCRC and the APC must get approval from the campus Physical Sciences Divisional Committee for any significant changes to courses, or new courses, degree programs, and certificates. Physical Sciences Divisional Committee ensures that proper procedures have been followed; for example, they ensure new courses have no significant overlap with other

Although each department has shared responsibility for the curriculum in a given program, individual faculty members have autonomy in their teaching of a given course. They are responsible for selecting a textbook, organizing content, and conducting a course in a manner that meets the desired Student Outcomes and Educational Objectives. Although each faculty member brings their own technical interests and style to a course, the content adheres to the requirements laid out in the official course description.

The UW departmental structure has created a culture in which the individual faculty members feel personally responsible for the success of the program. Collectively, the faculty are responsible for developing the program and ensuring that it meets the objectives, and individually, the faculty are responsible for carrying it out. The input from our constituents and stakeholders, including the other bodies of the university, is vital to the development of our program, but the program is a creation of the faculty.

While faculty in departments are responsible for developing and implementing processes to assess Program Educational Objectives and Student Outcomes and enacting continuing improvement, their efforts are supported at the College level by deans who have established a College-wide ABET committee composed of department representatives that attend monthly ABET meetings chaired by the Associate Dean.

The COE deans have made a significant commitment to continued improvement in education college-wide. For example, in 2007 they instituted funding through what was then called the Dean's Engineer of 2010 grant program, which since then has been renamed Engineering Beyond Boundaries (EBB or EB2) grants for innovative undergraduate pedagogies that meet emerging needs. Since then the deans have also provided funding through differential tuition grants that can be used to address significant bottlenecks in the curriculum or upgrades for laboratory equipment used by undergraduates.

The College has also been involved in helping to streamline the assessment process by seeking an innovative assessment software system that integrates course homepages, course syllabi, curriculum maps, faculty CVs, student learning outcomes across the curriculum, and continuous improvement processes to enable easier generation of assessment reports. While the synchronization of such software with current College and student records databases has proved challenging, the College is in the process of piloting the Academic Evaluation, Feedback, and Intervention System (AEFIS). Since this software is relatively new, the College has plans to implement it in stages to make the assessment process ultimately more sustainable for programs.

The university administration supports assessment directly through the Office of the Provost, which works collaboratively with the University Assessment Council to provide assistance to departments in developing assessment strategies. Discipline-specific assessment data are kept as a resource for faculty inquiring about assessment techniques, costs, and benefits from other comparable departments and institutions. Based on proposals submitted by representatives of the University Assessment Council, the Office of the Provost has made available financial assistance to those departments in the

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courses on campus and that appropriate notification has been made to departments with similar material.

developmental stages of assessment. Other groups on campus that provide assessment resources include Testing and Evaluation, the Office of Quality Improvement, and the University of Wisconsin Survey Center, which has been active in helping departments develop online student evaluation surveys, alumni surveys, and employer surveys through the use of the Qualtrics database.

The university also provides multiple avenues for faculty to share innovative teaching strategies. For example, the Teaching Academy is a campus-wide organization that promotes teaching and learning on this campus and nationally by encouraging innovation, experimentation, and dialogue among faculty, instructional staff, and teachers of the future. The Fellows of the academy are faculty, academic staff, and outreach instructors who have demonstrated excellence in teaching and a commitment to improving the quality of teaching and learning across this campus. The annual Teaching and Learning Symposium is a university-wide conference, organized by the Teaching Academy, where innovations in teaching and assessment can be shared. The Teaching Academy sponsors many other teaching development activities throughout the year, including a Fall Kickoff Symposium, a Winter Retreat, and a Summer Institute.

The Teaching Academy, through the Provost's office, sponsors the program on Teaching and Learning Excellence. Among the myriad of activities is the Delta Program, which is specific to the STEM disciplines. The Delta Program promotes the development of a future national faculty in the natural and social sciences, engineering, and mathematics that is committed to implementing and advancing effective teaching practices for diverse student audiences as part of their professional careers. While the original focus of this program was on developing teaching methods of graduate students, Delta has come to have a profound impact on evaluation and assessment as graduate students work in concert with faculty. Delta aims to improve undergraduate education on the UW–Madison campus in the sciences, mathematics, and engineering through the use of **Teaching-as-Research** by graduates-through-faculty (defined as graduate students, postdoctoral researchers, academic/instructional staff, and faculty).

Faculty participation in these many programs is voluntary; however, it is estimated that at a majority of the faculty in the College of Engineering have participated in one or more of the available programs. Thus, these programs have had a significant impact on the ability of faculty to address the issues of teaching, learning, assessment, and evaluation in their classrooms and departments.

CRITERION 7 – FACILITIES

The educational facilities in the CBE department are described here. Our classroom, laboratory, and computer facilities are continually being updated. Since the last accreditation visit in 2006, several projects to upgrade our facilities have been completed.

7.A Offices, Classrooms and Laboratories

7.A.1 Offices

Offices are adequate for all staff (administrative, clerical, academic, and faculty). Individual offices vary by location but are standard sizes consistent with state building guidelines in force at the time of building construction. Teaching assistants are all also research assistants and have shared offices near their research environments; they may conduct TA office hours in departmental conference rooms or in their own office spaces.

These administrative personnel and the faculty and academic staff in the program have access to computers, computer networks, printers, copy machines, fax machines, and office furniture and configurations that enable them to do their jobs effectively.

7.A.2 Classrooms and associated equipment

Classrooms on the engineering campus include both General Assignment (GA) rooms and special purpose rooms; the GA rooms used for many engineering classes are identified and assigned through a campus-wide online system, and the special purpose rooms can be requested and assigned when a class requires special technologies or capabilities, as in the case of specialized labs or computer classrooms.

The General Assignment rooms include 27 rooms in Engineering Hall, 10 rooms in the Mechanical Engineering building, and 3 rooms in the Materials Science and Engineering building. These GA classrooms vary in size from lecture halls of 258 seats to small classrooms of 24 seats, and all of these classrooms are equipped with an Instructor Station that includes a Windows computer (with internet access) hooked up to an overhead projector, a laptop jack, DVD/VHS capability, and a projector screen. Roughly half of these rooms also have document cameras installed; several of these rooms currently have whiteboards installed, and some rooms that currently have chalkboards are in transition to whiteboards. Seating for students in these GA classrooms includes either fixed-in-place seats and desks or movable tables and chairs, which are useful for team-oriented classes. A complete list of General Assignment Classrooms available on campus is available at http://www2.fpm.wisc.edu/support/Classrooms/Attributes.htm.

Most chemical engineering classes meet in three rooms conveniently located in the same wings of Engineering Hall as the Department offices and laboratories. Because instructional space is assigned campus-wide through the UW Instructional Space office, a few classes meet in other wings of Engineering Hall, or even occasionally in nearby buildings when class conflicts or specific room requirements dictate. Our three primary classrooms are the locations where most lectures and recitation sections for chemical engineering classes are held. All three rooms are equipped with conventional chalkboards, overhead projector, video projector, computer podium, and laptop projection interface. Room capabilities are:

2239 Engineering Hall (classroom seating for 49)

3024 Engineering Hall (classroom seating for 54)

3032 Engineering Hall (classroom seating for 63).

Larger lecture classes may be required to meet in any of several lecture halls in Engineering Hall or nearby engineering buildings. The lecture halls are also equipped with overhead projector, video projector, computer podium, and laptop projection interface. Most often used are:

1227 Engineering Hall – lecture theatre seating for 103, equipped with dual vertical sliding black boards, document projector, video projector, computer podium, and laptop projection interface.

1610 Engineering Hall – lecture theatre seating for 130, equipped with dual document projectors, video projector, computer podium, and laptop projection interface.

2535 Engineering Hall – lecture theatre seating for 76, equipped with dual vertical sliding black boards, overhead projector, video projector, computer podium, and laptop projection interface.

Other classrooms used for chemical engineering classes have similar general and specialized capabilities. In addition to our formal classrooms, 1119 Engineering Hall is a conference room with seating for 12 in which our faculty and teaching assistants meet with small groups of students for various purposes (group projects, office hours, help sessions, tutorials, review sessions for exams, etc.). This room has ample blackboard and whiteboard space on three walls.

7.A.3 Laboratory facilities

Separate laboratory facilities have been developed for our various laboratory courses. CBE 324 – Transport Phenomena Laboratory meets in the spring and fall semesters in the B103 Engineering Hall space used in the summer by CBE 424 – Operations and Process Laboratory. These courses share much equipment. Our primary laboratory rooms are described below. A listing of major equipment is provided in Appendix C. Detailed lists of equipment used in each of our required or elective laboratories are on file and are available for inspection during the site visit. All of these laboratories have benefited in the last 6 years from special initiatives (either via the DIN process associated with the State budget or via capital exercise monies associated with the return on overhead from grants) to upgrade equipment or add new experimental capabilities. A full listing of DIN-funded acquisitions will be available at the site visit.

CBE 324/424 – Transport Phenomena/ Operations and Process Laboratory (B103 Engineering Hall, also utilizes a dedicated classroom, B103D – the Ragatz Room). CAE also has a satellite computer facility with 10 work stations in a room adjacent to this laboratory.

CBE 470 – Process Control (1102C Engineering Hall)

CBE 541 – Polymers Laboratory (B46 Engineering Hall)

CBE 561 – Biochemical Engineering (1102A Engineering Hall)

Renovation of the Chemical Engineering portion of Engineering Hall has resulted in upgrades of the utilities and physical facilities and is a continuing process. All classrooms, laboratories, and offices have central air conditioning. All fume hoods in the building were replaced with variable-volume hoods using occupancy sensors as part of a campus energy conservation issue.

The chemical engineering core laboratory facilities are supervised by Dr. Eric Codner. His academic staff job classification of Laboratory Instrumentation Innovator aptly summarizes his objective of improving the facilities through modernization and upgrades of existing equipment as well as periodic design, construction, and implementation of new capabilities consistent with course development. He is supported in this by Machinist Joel Lord in the Chemical Engineering Department machine shop. This shop is a department facility that provides expertise to both undergraduate lab activities and graduate research programs. The shop has general capabilities such as lathes, mills, a CNC mill, welding facilities, and other equipment suitable for the range of projects needed by the department. Advanced machinery is operated by Mr. Lord, Dr. Codner, or skilled assistants, while general-purpose machinery may be operated by students after suitable training. Mr. Lord also cooperates with the general College shop facilities when appropriate for particular project capabilities or timelines.

The Student Machine Shop, located in the Engineering Centers Building, is available to all COE students who get training and receive a permit. For labs and student organizations in engineering, the Shop provides training and access to many machines, including both manual and CNC mills and lathes, drill presses, grinders, belt sanders, band saws, and additional equipment used in various educational training/manufacturing operations. The Shop also houses a full wood shop, welding lab, CADD/CAM Lab, and sheet metal lab. A staff comprised of both professional instrument makers and trained students are available to assist and educate engineering students engaged in work in the shop. These resources are used to support the instructional and research goals of the University of Wisconsin's College of Engineering. A layout of the student shop and more details about shop policies, safety rules, training, and the individual machines is available online at the College of Engineering Student Machine Shop website. For more details, see http://coestudentshop.engr.wisc.edu/index.php. The Student Machine Shop is open M-Th 8am to 9pm and Fridays 8-4pm.

7.B Computing Resources

7.B.1 Computer Resources in COE

The Computer Aided Engineering (CAE) Center of the College of Engineering provides computing resources to support the instructional and research programs of the College. Support is provided in several areas, including operating and maintaining instructional and open labs, managing the network for the College, and providing consulting, training, and technical support to users throughout the College. CAE manages approximately 400 Windows and 100 Linux computer stations in 20 locations around the College. Some labs are arranged as formal computerized classrooms and some are simply drop-in work zones. More than 200 of the workstations are available twenty-four hours a day. Although many labs have a fairly traditional layout, newer labs are being configured to enable and encourage group collaboration. Ten labs are configured to be used as formal computerized classrooms. Availability of computers in each lab can be checked online at any time. The computers are replaced every three to four years. All labs provide access to local printing.

Every student enrolled in an engineering course receives a CAE account on these systems and is given access to our desktops, software, generous disk space for saving course work, and 300 print units per semester for printing course-related papers and homework assignments. Students enrolled in certain project-intensive courses are given additional disk space.

The CAE facilities are dispersed around the Engineering campus in dozens of locations and are easily accessible by our students. In addition to these facilities, those undergraduates conducting independent study projects have access to the variety of computer facilities of the research group in which they are working.[1]

In addition to the facilities provided, CAE supports hundreds of software packages, with over 100 designated for use in specific engineering courses or disciplines. The remaining applications are of general use for communications, document processing, programming, etc. Some of the applications owned and managed by CAE can be accessed by faculty, staff, and students anywhere on or off campus as tethered software; users with a CAE account simply logon to the network and authorize their computer for temporary use of the tethered software. Wireless access to the network is available virtually anywhere on the UW campus for those with personal laptops.

CAE continues to see an increase in demand for engineering software outside of the traditional computer labs. To address this, CAE has deployed remote access in two methods - a compute server and "tethered software" access. Where possible, we have negotiated software agreements that allow students to install engineering software packages on their personal computers, yet "check out" a license from our pool from anywhere on the Internet - including the campus wireless network.

CAE develops and maintains software packages that help support teaching in the college. The highest profile of these tools is eCow (Engineering Courses On the Web), a course management package built on Moodle that is simple and easy for faculty to use. CAE has also developed custom modules to improve the utility to Engineering and scientific courses. In addition, the college has formed a new Teaching and Learning Service group to help instructors adopt technology in the classroom, such as Moodle and lecture capture.

7.B.2 Computer Resources Campus-Wide

During times of high demand for computer labs, other campus computer facilities are available. The UW-Madison Division of Information Technology (DoIT) provides general-access computer labs at many locations (in university libraries, dormitories, and student centers). Use of the labs is free for anyone with a valid UW-Madison ID. InfoLab software offerings include many popular word processing, spreadsheet, desktop

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[1] Additional information on CAE capabilities and services can be found on the CAE website: http://www.cae.wisc.edu.

publishing and graphics software as well as course-specific offerings. Applications are available for both Macintosh and Windows, and hardware includes scanners, video editing resources, color printers, and poster printers. Laptops are also available for 3 day check-out. In addition to these computer labs, there are approximately 33 computer kiosks available in different locations across the university campus. In short, students in the College of Engineering have ample access to convenient and up-to-date computing facilities.

7.B.3 Technology Enhanced Teaching and Learning in COE

Beyond computing resources available to the students, the College of Engineering has been working since 2007 to expand the capabilities of the online teaching tools used by faculty. This initiative in Technology Enhanced Learning, known as the TEL Project, has focused on development of a Science Technology Engineering and Mathematics (STEM) enabled online Learning Management System (LMS) for course pages, which is based on the Moodle platform and is called "eCOW2". The transition from the older, locally developed courseware (eCOW) to this new environment (eCOW2) has been taking place steadily for the past five to six years. Students and faculty have been taking surveys on the enhanced features of the platform, and Teaching Improvement Program sessions (offered at the beginning of each semester for faculty and teaching assistants) have focused on the sharing of best practices for technology-enhanced learning. The new enhanced Moodle environment allows for synchronous and asynchronous online discussion, mathematical materials in any content, a basic drawing tool, online quizzing, calculated and numerical quiz questions, online gradebooks, and online student work submission, among many other features. These features provide students and faculty with a great deal of flexibility, clearer communications, and overall enhancement of the learning experience.

To expand their impact on College of Engineering teaching, learning and research, the Engineering Learning Center, Engineering Media Services, and the engineering library (formerly Kurt F. Wendt Library) have been consolidated under the new name "Wendt Commons." This consolidation provides college faculty and staff a "one-stop-shopping" approach to teaching and learning services that will support increased innovation in teaching and technology-enhanced learning. Wendt Commons now brings together a team of educational professionals, including an instructional designer with engineering/scientific pedagogical and teaching expertise, learning technologists, media specialists, IT professionals, and librarians. They provide support for faculty and students in the following ways:

1. Learning to use eCOW2/Moodle or other learning technologies.
2. Using and creating video and other rich media.
3. Improving students' information use via information skills development sessions and/or resource pages.
4. Strengthening proposals for engineering education-related grants and awards.

In addition to these facilities, those undergraduates conducting independent study projects have access to the variety of computer facilities of the research group in which they are working.

7.C Guidance

The Computer Aided Engineering (CAE) Center provides guidance through online tutorials that walk new students, faculty, and staff through the processes of accessing a computer on campus, getting a CAE account, getting an email account activated, and using the available CAE software. Their online tutorial is called FastStart.[2] CAE provides helpdesk services to students, faculty and staff, and the emphasis is on helping all of these constituents make best use of the resources CAE provides for them. Helpdesk services are provided in person, via the phone, or via email. Student consultants are available 16 hours per day during the week and for 12 hours per day on weekends. Phones are available in all the remote labs to allow users to contact the helpdesk without having to leave the lab. CAE employs academic computing support staff (8 full-time equivalent) and around 25-30 student workers (around 10 full-time equivalent) to support all of the systems, facilities, and instructional tools they deliver.

Guidance for computer security for students on the UW campus is also provided through the Division of Information Technology (DoIT). This division assists new students in activating a personal NetID, which is the campus identification system that enables students to securely register for courses, attain a campus email address, check their financial aid status, access library resources, login to campus wireless networks, and many other identity-sensitive functions. They are a first line of defense to protect students from computer or personal identity fraud: DoIT dictates that every computer connected to the University network must have the latest security-related patches and must run up-to-date antivirus software. They require that students enable the Windows or Mac OS X built-in firewall and install anti-spyware software. They recommend that students see the Campus Information Security Website[3] for the latest information and advice about protecting personal computers; at that site, students can download software to provide personal computer security.

Safety training and proper use of laboratory equipment is also emphasized in every lab in the College of Engineering. For example, students, faculty, and staff wishing to use the Student Machine Shop must obtain training and a shop permit. There are three different permits, each providing a certain level of training and access to shop resources. Video instructions on the safe use of shop machines and online quizzes are available in eCOW2, though some permit levels require that students demonstrate effective use of different machines. Students using the shop are expected to have their permit with them, and while working in the shop, the permit must be worn visibly. For more information about the permitting process, details are available online at the COE Student Shop website.[4]

The UW-Madison Environmental Health and Safety Engineering program offers training for all student employees, faculty, and staff working in the following areas: biosafety, chemical, radiation, animal research, and occupational health. The UW-Madison EH&S Environmental Compliance program works to ensure campus-wide observation of

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[2] Available at http://www.cae.wisc.edu/caefaststart.

[3] The Campus Information Security Website is at http://www.cio.wisc.edu/security-downloads.aspx

[4] The COE Student Shop website is at http://coestudentshop.engr.wisc.edu/permit/index.php

federal, state and local environmental regulations for campus air emissions, emergency and hazardous chemical inventories, infectious waste, oil spill prevention and control, pesticide use and stormwater management. In addition, the Environmental Compliance program works closely with the Chemical Safety Office, which oversees and provides guidance for campus chemical use and storage as well as hazardous waste management.[5]

The UW-Madison Environmental Health and Safety Engineering program provides basic safety training to all program undergraduates in a scheduled activity in CBE 324 – Transport Laboratory. Early in each semester a chemical safety specialist from the campus safety program takes each afternoon laboratory group through standardized training with a presentation and demonstrations of safety equipment. Some semesters students can obtain experience discharging fire extinguishers. The training activity culminates in an online test that validates their new expertise and documents course completion in a campus database. This training provides a common base for all undergraduates in the program. Students who proceed to do more specialized laboratory work in CBE 599 – Independent Study projects receive appropriate training for this as required by the Chemical Hygiene Plan of the research group with which they are working, as described below in section 7.F., or from campus training programs addressing biosafety, radiation, or other specialized aspects of laboratory safety as required by the Chemical Hygiene Plan.

7.D Maintenance and Upgrading of Facilities

In general the laboratory and classroom facilities available for undergraduate instruction in the College of Engineering are maintained and upgraded regularly by the UW-Madison Space Management Office (for furniture, electrical work, and HVAC), Engineering Media Services (for instructional technology in the classroom), and Computer Aided Engineering (for computer workstations, software, and related network capabilities). The replacement of fume hoods throughout Engineering Hall mentioned in the Laboratory section above was part of a campus-wide energy-saving initiative by We Conserve (UW Physical Plant special project). Some fairly significant recent renovations have provided for improved laboratory space in the Mechanical Engineering building; other, more regular maintenance and upgrade efforts are also described below.

The Mechanical Engineering Building has undergone a $50.5 million construction and renovation project, completed in 2008. Shared by the Department of Industrial and Systems Engineering and the Department of Mechanical Engineering, the building will give its occupants technological flexibility for years to come. The building now encompasses more than 270,000 square feet of new and completely renovated space. All of the floors are reinforced to accommodate heavy laboratory equipment, and some of the floors are vibrationally isolated to facilitate delicate, cutting-edge research on the nanoscale. The new and renovated space features several architectural upgrades, including state-of-the-art ventilation, power and smoke-evacuation systems, as well as central heating and air conditioning. In addition to engineering upgrades and technology

[5] More information on the Campus Environmental Health and Safety Office can be found at http://www.ehs.wisc.edu/index.htm

for teaching, the new building includes much-needed flexible classroom space, including three large lecture halls and seven smaller classrooms outfitted with multimedia technology. Like all of the main buildings on the College of Engineering campus, the entire building boasts wireless Internet service. Designed to foster interaction and collaboration, two multistory atria and spacious conference rooms provide places for students and faculty to work together.

Computer Aided Engineering maintains and upgrades the computing resources for students annually. Since CAE is the primary resource for computing in the College of Engineering, they are well supported by the College: CAE has a base hardware upgrade fund of $200,000 every year, and that level has on occasion been increased to as high as $400,000 a year when new buildings or new computing facilities have required an increase in capacity. CAE has the following policies and procedures for maintaining and upgrading their facilities:

- CAE replaces computing hardware in its student computer labs every four years.
- CAE upgrades engineering software packages every year, particularly when vendors have released a new upgrade on a package; their policy is never to be more than a year behind on software upgrades.
- CAE upgrades desktop operating systems yearly; their policy is never to be more than a year behind on operating system upgrades.
- CAE works closely with the Teaching and Learning Services in Wendt Commons to ensure that instructional support to COE faculty and staff is backed up by the best computing resources possible. While Teaching and Learning Services are the conduit between CAE and COE faculty and staff, these two groups must collaborate effectively to make support for faculty and staff seamless.
- When a need becomes apparent for additional computing resources that exceed the base hardware upgrade fund provided each year, CAE will secure Decision Initiative Narrative (known as DIN) funding to procure the necessary resources. (DIN funding is described in more detail below.)

CAE is constantly seeking the best computing resources for students in engineering; in particular, they are always working on new methods to deliver desktop operating systems for students, since an increasing number of students demand access to operating systems or software while off campus.

Engineering Media Services maintains and upgrades all of the “General Assignment (GA) classrooms on the College of Engineering campus. The GA classrooms available in Engineering Hall, Materials Science and Engineering Building, and Mechanical Engineering have been continuously updated as the engineering faculty adopt more technology-enhanced learning tools. Three auditoriums in Mechanical Engineering and two in Engineering Hall are MediaSite-capable rooms, meaning that instructors can request recordings that are professionally filmed and placed online by Engineering Media Services. Several other rooms were installed in Summer 2011 and Fall 2011 with “Lecture Capture” technology, which is built-in recording equipment that allows instructors to videotape themselves or their students; these technologies facilitate online learning or make possible an online backup of a lecture in case students miss class. Updates to the engineering classrooms are continually being done to ensure that technologies are as current and reliable as possible; new computers for instructor stations are installed regularly, document cameras have been added to many rooms, and whiteboards are being exchanged for chalkboards where necessary.

Every program in the College may solicit grant funding for instructional technology upgrades through the Decision Initiative Narrative (DIN) grant. Typically when a faculty member or a lab manager identifies a need for technology improvements, they submit a DIN proposal to the department chair; these proposals can be for lab equipment, software, computing resources, or specialized classroom technologies that support undergraduate education. Each year the chair has the faculty and staff requesting DIN funding review the proposals of their colleagues, and a ranked list reflecting department priorities is forwarded to the College by the department. The College deans have final decision-making authority over who receives DIN funding.

7.E Library Services

The campus libraries provide a strong core information infrastructure with an increasing emphasis on digital collections. The campus library system has the 11th largest research library collection in North America, according to a survey by the Association of Research Libraries, which includes more than 7 million volumes. The Wendt Commons Library serves all College of Engineering departments as well as the Departments of Statistics, Computer Sciences, and Oceanic and Atmospheric Sciences. It has an extensive research collection of journals, books, government documents, specifications and standards, technical reports, and patents. As part of the University of Wisconsin System, faculty and students have access to an additional 13 research university libraries containing more than 55 million volumes and can place requests for these materials to be delivered to campus via MadCat, the Libraries' online public access catalog. The library can borrow or acquire additional material, as requested by students and faculty, from national and international sources. Online access to databases, ebooks and journal subscriptions allows convenient access to many additional information resources.

Wendt Commons Library also provides students with support and opportunities for developing their skills in discovering, using, and managing information. This is achieved through course integrated information skills development, specialty workshops and tutorials/self-help available via the Web. In addition, librarians teach a one-credit course on technical information resources. This library instruction program has continued to reach more students each year with over 4900 students attending a session in FY10.

The dramatic shift to digital collections has presented opportunities to use library space in new ways. In Fall 2011, Wendt Commons will open a completely renovated 4th floor that will provide multi-purpose space that will provide a dynamic, technology-enhanced teaching space (Wisconsin Collaboratory for Enhanced Learning, http://wiscel.wisc.edu), as well as expand support for group study and for supplemental instruction and tutoring. Students also make use of other library facilities distributed across the campus for both individual and group study.

7.F Overall Comments on Facilities

The Department Safety Committee takes an active role in ensuring that safety planning and training is current and that documentation is maintained. The chair of the Safety Committee is Prof. Lynn, who was trained as a Chemist and has a joint appointment in the Department of Chemistry. Thus, the safety culture in the department instructional and research labs is maintained at the higher level typical in chemistry compared to most engineering facilities. All undergraduates have substantial exposure to experimental operations and associated safety procedures in the instructional laboratories, and the many who conduct research in CBE 599 projects are exposed to more advanced facilities and specialized precautions in their research group laboratories. Management of instructional laboratories is the direct responsibility of Dr. Eric Codner, who is also a chemist. Research groups each have a designated lab manager (a post-doc or senior graduate student) responsible for the safety program. Each lab manager ensures that emergency contact information and warning signs are posted. Each lab manager is provided with safety checklists and notebooks on materials safety procedures relevant to the particular work done in that lab. The lab managers are also responsible for compliance with training standards as outlined by the lab-specific Chemical Hygiene Plan (see below) and documenting that all students active in the lab have received the required training. The Engineering and Technical Services division of the Department of Environmental Health and Safety conducts a safety inspection of all facilities within each department every year.

The Occupational Safety and Health Administration (OSHA) has developed numerous workplace regulations designed to prevent injuries and protect the health of workers. Laboratories are unique workplaces and in order to address the worker protection needs of these facilities OSHA developed a standard, Occupational Exposure to Hazardous Chemicals in Laboratories (29 CFR 1910.1450). This standard, often referred to as the OSHA Laboratory Standard, imposes many requirements, including developing a written Chemical Hygiene Plan. The complete Chemical Hygiene Plan (CHP) for all university laboratories consists of three parts: The UW-Madison Campus Chemical Hygiene Plan and Compliance Guide, a laboratory-specific CHP, and the UW-Madison Laboratory Safety Guide.

The UW Madison Campus Chemical Hygiene Plan and Compliance Guide outlines roles and responsibilities for key personnel, contains policies and practices applicable to the entire campus, and provides an overview of the various regulations applicable to operations in a campus laboratory. It also provides information on other regulations such as fire codes, hazardous waste regulations, chemical shipping requirements and other requirements pertaining to the use of hazardous chemicals in the laboratory.

The Laboratory Chemical Hygiene Plan contains instructions to enable each Principal Investigator or their laboratory's Chemical Hygiene Officer to prepare a laboratory-specific Chemical Hygiene Plan that includes the following information specific to their laboratory's operations:

- Standard operating procedures (SOPs)
- Personal protective equipment (PPE) requirements
- Engineering and administrative controls

- Provisions for handling Particularly Hazardous Substances
- Provisions for designating specific operations that shall require prior approval before initiating Training prerequisites.

The Laboratory Safety Guide is prepared by the Chemical Safety Office within the Environment, Health & Safety Department (EH&S). It contains a wealth of information, including specific practices and procedures for the safe use and disposal of chemicals.

UW Environmental Health and Safety oversees lab safety on campus, and employs a number of professionals who conduct safety checks of all labs on campus on a regular basis. They are responsible for annual inspection of laboratory safety equipment such as safety showers, eye washes, and fire extinguishers; these inspections are documented appropriately. One contact person with EH&S who can provide further information is Todd Yanke (608-890-0003), a supervisor in charge of the laboratory safety visit program who ensures laboratory regulatory compliance and fume hood safety. Much more information about the roles of EH&S in assuring safety of facilities on campus can be found at their website, http://www.ehs.wisc.edu/index.htm.

The umbrella organization which houses the EH&S office is Facilities Planning and Management (FP&M), which is responsible for the maintenance of campus buildings, vehicles, grounds, and utilities. FP&M collects, maintains, and analyzes information about University space use. The office coordinates the allocation and reassignment of existing space and participates in the planning for modified or new space. This organization works with faculty, staff, students, and the surrounding urban community on physical planning issues, including implementation of the Campus Master Plan. The FP&M website provides more details about facilities management at http://fpm-www3.fpm.wisc.edu/FPM_Portal/Home/tabid/59/Default.aspx.

CRITERION 8 – INSTITUTIONAL SUPPORT

8.A Leadership

Leadership of the Chemical and Biological Engineering program is provided by the department chair and supporting departmental committees. Committees affecting the undergraduate program were presented in the Background section; the full committee structure can be provided by request or may be viewed at the visit if desired. The chair is the appointed executive of the department who oversees the day-to-day operations. The chair is selected by the Dean based upon an annual preference ballot provided by the department faculty and staff.

The chair calls meetings of the departmental and executive committees and presides over the meetings, administers the department budget and makes teaching assignments. The chair is responsible for ensuring that all necessary records of teaching, research and public service of the department are properly kept. This leadership position serves as the official channel of communications for all matters affecting the department as a whole, between the department and the chancellor, the dean, other university officials, or departments. All department chairs attend individual and group meetings with the dean on approximately a monthly interval, where they report on the activities and needs of their departments.

The chair's leadership is derived from the departmental faculty and in particular the department's executive committee. As discussed under Criterion 6 Section E, shared governance is a fundamental component of the University of Wisconsin as established by state statute. Shared governance means that Faculty and Academic Staff members, through their representatives, actively participate in the governance and policy development of the institution and have representation in matters that affect them along with student representatives and the administration of the university and colleges. These rights are established through the Wisconsin State Statutes Chapter 36, available at the Secretary of the Faculty website.[1] The current rules were codified in 1978, but the structure has been in place since the founding of the university in 1848.

The departmental executive committee is composed of all tenured faculty members of the department and to whom the department has a continuing commitment of one-half time or more. The departmental executive committee has authority to make recommendations concerning personnel actions and other departmental budget matters. This day-to-day budget responsibility is delegated to the Chair for the purposes of practical operations. The department faculty and the department executive committee generally meet every two or three weeks during the academic year, and as needed during the summer.

The departmental executive committee conducts a periodic review of the performance of every faculty member. In the Chemical and Biological Engineering department, this review is conducted as part of the annual determination of recommendations for merit salary increments. The executive committee also provides to its associate professors the expectations for promotion to full professor. Additionally, an annual review of each of its associate professors' progress toward promotion to full professor status is conducted. The departmental executive committee also conducts an annual evaluation of every probationary faculty member beginning with the second year of the initial appointment.

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[1] The Secretary of the Faculty website is available at www.uwex.edu/secretary/.

8.B Program Budget and Financial Support

8.B.1 Program Budget and Continuity of Institutional Support for the Program

The Dean of the College of Engineering, in consultation with the Department, determines the instructional budget for the program. Currently four funds may contribute to the undergraduate instructional program budget. These four funds will be referred to as the base general program revenue fund (GPR), the Engineering Differential Tuition (EDT) funds, instructional labs and technology fund (referred to as DIN), and the Madison Initiative for Undergraduates (MIU). Specific gift funds may support undergraduate instruction but these funds are not a significant portion of the program instructional budget. Any exceptions will be noted later.

The GPR fund is the largest source of instructional funds by approximately an order of magnitude and is derived from tuition and state tax revenues assigned to the University. GPR allocations to the College and to the departments are based on historical allocations that are adjusted for current events. There is an ambition to allocate a portion of these funds to both the colleges and to the departments within the college based on certain performance metrics, however, over the past 6 year-period allocations are based primarily on a prior year baseline.

The Engineering Differential Tuition (EDT) funds are allotted to fulfill specific objectives. These objectives include student access to core courses and services to facilitate timely graduation, hands-on instruction including shop and laboratory experiences, and instructional innovation. The role of input from the undergraduate engineering student organizations in implementing the EDG surcharge and in setting priorities for use of these funds to enrich the undergraduate engineering education experience has been described in substantial detail in Criterion 4 – Continuous Improvement, section 4.C.2. The EDT plan was phased in over a three-year period and is paid by engineering students once they enter their degree-granting program. The surcharge over base UW tuition began in 2008 at $300/semester in 2008, and in 2011 reached its plateau level of $700/semester. These funds are distributed by the College among programs based on requests and proposals from each program that address the objectives. Proposals are evaluated by a committee of faculty, staff, and students who make recommendations to the Dean. EDT has allowed significant investments to be made in COE education. For example, in year 2010-2011, EDT made up about 5% of the instructional budget and was invested in the categories of instruction (47%), hands-on instruction in shops and labs (30%), student services (11%), and innovation in engineering education (14%). For example in the category of instruction, during the Spring of 2011 over 700 additional course seats were opened in high-demand core courses to reduce or eliminate waitlists.

DIN funds are used to support undergraduate computing, related information technology services and undergraduate laboratory upgrades and equipment replacements. These funds are distributed to technology related support services and program laboratories for equipment purchases and upgrades. Each program submits requests to the dean’s office. These requests are reviewed by the associate dean and one or more faculty or staff, and funds are allocated to the most deserving requests.

Figure 8.1 shows the instructional funding for the Chemical and Biological Engineering Dept. from the combined sources of GPR, EDT and DIN for the last six years normalized to the budget in FY 2006-07. The values are actual dollars not adjusted for inflation.

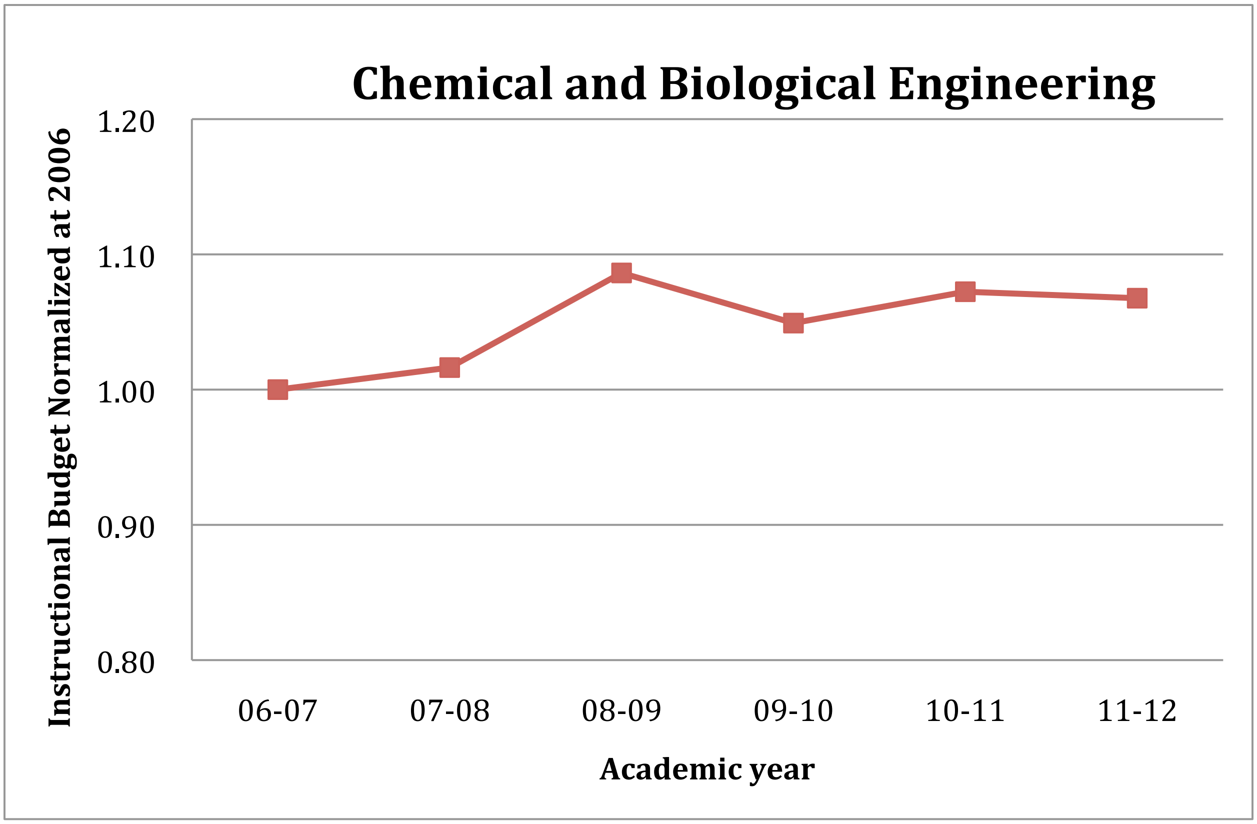

Figure 8.1 Instructional budget continuity for Department of Chemical and Biological Engineering

8.B.2 Institutional Support for Graders, TAs, and Teaching Workshops

Teaching assistants and graders are hired by the Department of Chemical and Biological Engineering according to well-developed departmental policies. Teaching assistants (TAs) are generally drawn from the graduate student population in the department. The Ph.D. degree requirements specify that each graduate student shall participate in undergraduate instruction as a TA at least twice. Most graduate students fulfill their TA obligation during their second and third years. The graduate student body of 120-140 students provides highly qualified personnel for the approximately 25 TA positions needed each semester. When additional TAs are needed, the department has been able to identify qualified graduate students in other departments who are willing to serve as TAs in courses matched with their backgrounds. Recitation section TAs receive a 25% TA appointment for one section, and laboratory TAs receive a 37.5% TA appointment in recognition of the greater duties. The College budget provides funding for approximately 7.75 FTE teaching assistants, and when the TA staff needed for a semester's courses is greater than this level the Department provides the needed funding from department discretionary funds available for student support. Teaching assistants have primary responsibility for conducting recitation sections and office hours, and also do some grading of exams and homeworks. Undergraduate paper graders are hired by the Department as needed to share the homework grading workload of the teaching assistants. Graders are hired from senior undergraduates with strong background in the course to be graded, and are paid on an hourly basis. The graders are paid from the same pool of College GPR funds, augmented by departmental resources as needed to maintain quality of education for students in the courses.

Formal teaching workshops for new and continuing faculty and teaching assistants are provided at the beginning of the semester in both Fall and Spring; they are administered through the Engineering Learning Center of Wendt Commons and funded by the College of Engineering. The Teaching Improvement Program (TIP) is designed for continuing faculty and staff; the New Educators Orientation (NEO) is designed for Teaching Assistants in particular. While all faculty and staff are encouraged to attend TIP, the NEO sessions are typically reserved for new graduate student Teaching Assistants, and their appointment requires them to attend. Both TIP and NEO typically involve two to three days of workshops on innovative teaching methods and technology-enhanced learning initiatives; some practical workshops are provided on creating course websites, grading, and safety, other workshops focus on teaching special topics like engineering ethics or technical presentations.

Informal mentoring for graders and TAs is quite common and is handled as needed by the faculty of record for the course. TAs work directly with the faculty of record to ensure consistency in performance expectations. There is a formal mid-semester review using a form from the Teaching Assistant Association (TAA) that documents how faculty provide feedback to the TAs on their skills at the job duties. At the end of the semester the College provides a standard, scan-tron TA evaluation form for feedback from the students in the recitation or laboratory section. Results of the TA evaluation are provided to the instructor, the TA's academic advisor, and to the Department for use in future TA assignments.

8.B.3 Resources for Acquiring, Maintaining, and Upgrading Facilities

An annual, state-funded, competitive grant program for acquisition of instructional capital equipment (known as DIN funding) is the primary funding source for modernization of instructional laboratories. When laboratory expansion impacts core course enrollment, EDT may also be used to fund such expansions and related upgrades. Maintenance and operation of laboratory equipment is achieved through departmental budget for personnel, services, and supplies. (DIN funding is described in more detail in Criterion 7D, Maintenance and Upgrading of Facilities.) The College of Engineering's Computer Aided Engineering (CAE) program maintains excellent computer facilities for use by undergraduate students (CAE is described in Criterion 7, section B.1.).

8.B.4 Adequacy of Resources for Enabling Students to Meet Outcomes

Public higher education is being asked to do more with less on nationwide basis and the same is happening in the College of Engineering. This trend has been countered by diversifying the revenue stream for instruction and strategically allocating those resources to achieve certain goals. Engineering Differential Tuition (described in Criterion 8, section B.1) has given the College the ability to provide more sections of key courses and better shop and lab equipment, while enhancing teaching through development of various technology-enhanced learning initiatives despite reductions in base budgeting. The additional tuition has not simply allowed the College to maintain a high quality educational experience; it has enabled us to educate more students, using more advanced pedagogical tools, building stronger multidisciplinary expertise, to better prepare students for the workplace of the 21st century.

8.C Staffing

Administrative, instructional, and technical staff in the department are sufficient for the needs of the program.

The administrative support structure is:

- ❑ Department Administrator – Christi Balas Levenson
  - o Student Status Examiner (graduate program) – Donna Bell
  - o Student Status Examiner (undergraduate program) – Linda Gatzke
  - o Tech Services – Mary Diaz
  - o Payroll & Benefits Specialist – Heidi Udelhoven

The technical structure includes:

- ❑ Administrative Program Specialist – Roger Packard
  - o Program Specialist – Andrew Greenberg (undergraduate research and outreach)
  - o Instrumentation Innovator – Instruction – Eric Codner (lab manager)
  - o Instrument Maker – Joel Lord (machinist)

The instructional staff includes academic staff Lecturer Rafael Chavéz-Contreras and partial duties of Dr. Codner and Dr. Greenberg. Their instructional duties are formally supervised by Undergraduate Associate Chair Regina M. Murphy.

Undergraduate students who have not yet matriculated into a degree-granting program are advised by a team of academic advisors in the College-run EGR office. Although a number of personnel changes have occurred in that office since the last comprehensive review, in 2011 two additional advisors joined that group with funds from the Madison Initiative for Undergraduates. The centralizing of staff in these units resulted in the adoption of standard best practices, uniform training and enabled staff to provide backup service in the case of an absence.

CoE academic programs receive administrative and financial support services which include financial management/reporting, accounting, payroll and human resource services. These services are provided by a combination of the central CoE Business Services administration group as well as support staff located in each academic department. The support staff in each department typically includes a Department Administrator who supervises an office administrator, financial specialist/accountant, payroll coordinator, and a research administrator.

Financial management and accounting services assist academic department Chairs and faculty with the fiscal planning and tracking of departmental programs. Accounting services processes purchases, reimbursements, and other fiscal transactions to help manage the day to day operations of the academic programs. In many instances, financial transaction assistance is provided directly to students in support of individual student projects or special programs and events.

Human resource support services include but are not limited to hiring faculty and other instructional staff such as lecturers, academic staff, and teaching assistants. Human resources also facilitate compensation adjustments, performance reviews and promotions as appropriate. Payroll services not only process bi-weekly or monthly payroll but also provide guidance on benefits, track salary payments by funding source, assist with visa processing and monitor paid leave reports.

Because of personnel rules imposed by the State of Wisconsin there are only limited options available to retain staff member if a more lucrative offer is received. Sometimes duties can be expanded or adjusted with a corresponding adjustment in pay.

College-wide, the training for staff positions varies widely: for instructional staff, programs mentor new instructors just as closely as new faculty would be mentored in their teaching duties; these instructors are encouraged to attend the Teaching Improvement Program and the New Educators Orientation, which offer workshops every January and August. Instructors are also encouraged to attend (and develop presentations for) the annual Teaching and Learning symposium offered by the UW Teaching Academy. A wide range of other professional development activities are available for instructional staff, many of which are detailed in section 8.E, as they overlap with the development activities available for faculty.

For administrative and technical staff positions, training is available on campus for the various duties that may be required; these duties may range from university-sponsored training in the ISIS student records system, to training in computer software or hardware through the Division of Information Technology. For supervisory positions, leadership and management training is available and sometimes required, often through the campus Office of Human Resources and Development; attendance at those workshops is supported and encouraged.[2]

8.D Faculty Hiring and Retention

8.D.1 The process for hiring of new faculty

The process for hiring new faculty is initiated from strategic planning within the home department of the program. Such planning considers anticipated or announced retirements, faculty departures and new needs. The hiring process includes a review of affirmative action needs prior to preparing a Position Description. The committee presents the plan to the departmental committee for discussion and approval, but discussions with the Dean are also initiated early, as the Dean's approval is required before a search for a suitable candidate is begun.

When the decision to hire a faculty member in a specific area is approved by the departmental committee and the Dean's office (with campus approval of salary range and the Position Vacancy listing), the hiring committee conducts a national, and in some instances, a world-wide search for the best available candidate. In general, the search is for a new faculty member at the Assistant Professor level, but in some situations a senior candidate is sought. The hiring committee advertises the position in the appropriate journals (Chemical Engineering Progress, Chemical & Engineering News) and websites. Appropriate advertising for the position helps ensure a sufficient and diverse pool of applicants; each of these stages, as well as the remainder of the process, must be documented. Once applications are received, the committee must respond to all applicants and review their materials; references are checked as needed. The hiring committee reviews the vitae of candidates for a given position, rates them as to quality and suitability, and presents the candidates to the departmental committee for discussion. Telephone screening interviews may be conducted. Suitable candidates are invited to visit

[2] Details on staff retention and training were supplied by Ms. Jeanne Hendricks, a senior administrative program specialist in COE Human Resources; she can be reached for further comments at jhendricks@engr.wisc.edu.

campus for an interview with current faculty, and they are typically asked to present a seminar on their research.

The departmental committee members are solicited for their opinions on viable candidates, but the decision to hire is in the province of the departmental executive committee and the Dean. The members of the executive committee discuss and vote on each faculty candidate. When a motion to hire is passed, the department chair consults with the Dean on the appropriate salary and start-up package. Before the Department Chair or Unit Administrator can send a Letter of Offer to the candidate selected for the position, a Checklist for Affirmative Action Recruitment and Hiring Procedures for Faculty, Academic Staff and Limited Positions must be completed. (Concerns regarding moving expenses must be addressed.) The candidate is informed about benefits available, and unsuccessful applicants are notified.

When it is possible to recruit someone from an under-represented area by securing a spousal hire, the COE may work through the Provost's office to explore dual-career opportunities, particularly when recruiting or retaining one hire has an impact on diversity. For more information on the Faculty Strategic Hiring Initiative, see the Provost's website on faculty hiring initiatives.[3] More details on hiring policies and forms can be found at the website for Unclassified Policies and Procedures, maintained by the Office of Human Resources Academic Personnel Office.[4]

Detailed advice for hiring faculty is provided to programs through the online UW-Madison Search Handbook, maintained by the Office of Human Resource and Development.[5] The handbook provides guidelines on everything from attracting diverse applicants, to framing appropriate interview questions, to managing logistics before, during, and after interviews.

8.D.2 Strategies used to retain current qualified faculty

The current College of Engineering Strategic Plan identifies faculty recruitment and retention as a critical strategy for achieving excellence in education. Retention of faculty begins with providing a supportive and collegial environment with strong mentoring within the given program. Assistant professors are assigned a mentoring committee to guide their professional development in both research and teaching. The department has been very successful in recruiting high-quality junior faculty and retaining them. Indeed, no assistant professor in the department has departed voluntarily or involuntarily since 1990.

Retention of senior faculty presents different problems. In the current economic environment salary increases have not existed since 2008. With similar conditions existing at other public universities, outside offers to faculty have not been as widespread as might be expected with stagnant salaries. A pool of funds has been set aside at the university level and distributed to the colleges to retain top faculty in both a pre-emptive and reactive basis. Senior faculty salaries are also considered through a five year equity review process whereby adjustments to salary can be made. If a current engineering faculty member receives an outside offer, the department chair and/or the dean may seek a salary rate increase through the campus in a retention effort. As noted in section D.1, the Provost's office supports a Faculty Strategic Hiring Initiative that

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[3] The Provost's Faculty Strategic Hiring Initiatives are available at http://www.provost.wisc.edu/hiring/facshi.html

[4] The OHR Academic Personnel Office website is available at http://www.ohr.wisc.edu/polproced/uppp/upppTableofContents.htm.

[5] The Office of Human Resource and Development website is available at http://www.ohr.wisc.edu/polproced/srchbk/sbkmain.html.

includes emphasis on retention of minorities and women in the STEM disciplines.[6] When a faculty member receives an outside offer, the chair works with the Dean to consider a number of different retention options to encourage the faculty member to remain at Wisconsin.

Significant efforts are made to ensure that the climate in the College of Engineering is supportive for faculty. For example, the Women in Science and Engineering Leadership Institute (WISELI) is an on-campus research group formed in 2002 with funding from the NSF to address equity issues in hiring, pay, and retention of faculty in science and engineering. The College of Engineering supports the mission of WISELI through encouraging faculty and staff to attend their workshops and through providing office space for the three full-time employees who work with WISELI. Notably, WISELI provides workshops for department chairs on enhancing department climate (http://wiseli.engr.wisc.edu/climate.php). Over the past years, eight of the nine department chairs in the College of Engineering have come through their climate workshops. WISELI has recently developed a new workshop titled "Attracting and Retaining Excellent Faculty through Bias Literacy," which focuses on enhancing awareness of unconscious biases and assumptions that may affect workplace behaviors. New department chairs, supervisors, directors, and search committees are encouraged to participate in these workshops. Finally, WISELI manages the Vilas Life Cycle Grant, which is available to sustain faculty in the STEM disciplines who are undergoing a life crisis; this grant has enabled some faculty to continue their research and remain at UW-Madison in spite of personal challenges.

8.E Support of Faculty Professional Development

Professional development of faculty is achieved primarily through their participation in research, in professional societies, and in professional meetings. Development of an outstanding research program is an expectation of all traditional tenure-track faculty appointments in the College of Engineering and is one primary criterion for promotion. All tenure-track and tenured faculty members are expected to publish in archival, peer-reviewed journals. This expectation ensures that faculty remain current in their field of expertise and that their intellectual work will pass review by colleagues in their respective fields. Some programs are able to fund this professional development through research contracts sponsored by government and industry. Most faculty travel funds are obtained through research contracts and grants. More details about the different professional development opportunities for faculty can be found in Criterion 6D.

The campus also has a sabbatical leave program for faculty and professional development or retraining grant programs for faculty and staff; these must be applied for in each department, and more information about these opportunities can be found at the website for the Office of Human Resource Development.[7] Departments provide the institutional funds for sabbaticals and reduced teaching loads for junior faculty. Research grants often provide funds for attendance at professional conferences and workshops. Industry funds provide for participation in consulting.

If funding for travel to an off-campus conference is required, and no research funding can be identified within the department, there are UW programs that may provide funds for professional development. In addition to the aforementioned faculty development grants, there are the University Teaching Improvement Grant (which is open to the full UW System), and the

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[6] For more information on Faculty Strategic Hiring Initiatives, see http://www.provost.wisc.edu/hiring/facshi.html.

[7] Available at http://www.ohr.wisc.edu/grants/facdevgrts.html.

Academic Staff Professional Development Grant (a campus-wide program). Funding for these programs is obtained through submission of successful proposals.

On campus, the Department, College, and University support professional development activities related to instruction through on-campus workshops, notably the College of Engineering Teaching Improvement Program (a program put on twice a year for engineering faculty, staff, and teaching assistants), and the annual Teaching and Learning Symposium, a university-wide conference promoting excellence in teaching, organized by the UW-Madison Teaching Academy. The Office of Human Resource Development at UW-Madison also offers learning and leadership workshops designed to reach out to all University employees; more information on these workshops and other professional development activities for faculty and instructional staff are documented in Criterion 6D of this self study.

PROGRAM CRITERION

PC.1 – Curriculum

The Program Criteria present a summary description that is in agreement with the continuing evolution and improvement of the program curriculum. Indeed, the current wording embodies the intent for preparation of our graduates for the broad range of professional paths they take much better than the 2006 Program Criteria with its detailed listing of content.

1. Curriculum: The curriculum must provide a thorough grounding in the basic sciences including chemistry, physics, and biology, with some content at an advanced level, as appropriate to the objectives of the program. The curriculum must include the engineering application of these basic sciences to the design, analysis, and control of chemical, physical, and/or biological processes, including the hazards associated with these processes.

These criteria are satisfied through the following groups of courses.

PC.1.a – *Basic through advanced sciences* courses are taken from the first through third years. The strong grounding is reflected in the 50+ credits being more than 50% in excess of the ABET requirement. Chemistry proceeds through General Chemistry, Analytical Chemistry, Organic Chemistry (2 semesters plus lab). The final required course is Physical Chemistry, containing quantum mechanics and statistical thermodynamics. The advanced organic and physical chemistry courses provide suitable foundation for chemical engineering courses in modern thermodynamics, polymers, and other modern materials. Physics preparation is through the full year of engineering-track physics, and this material prepares students well for the physics-based content of Transport Phenomena and Process Control courses in the program. Biology is covered by the Introductory Biology and Advanced Biology courses, which provide background for applications and examples throughout later courses in the program.

PC.1.b – *Engineering applications* of these basic sciences to a broad range of chemical engineering problem areas is accomplished through courses that may be attributed as follows.

Course	Design	Analysis	Control	Hazards	Main role or emphasis
CBE 250	x	X		x	M&EB – Intro to Analysis and Design
CBE 255		X	x		Computational Tools
CBE 310		X			Thermodynamics
CBE 311		X		x	Thermodynamics of Mixtures
CBE 320		X			Transport Phenomena
CBE 324	x	x		x	Transport Laboratory
CBE 326	x	X		x	Unit Operations – Momentum and Heat
CBE 424	x	x	x	x	Summer Lab capstone
CBE 426	x	X		x	Unit Operations – Mass Transfer
CBE 430	x	X		X	Reactor Analysis and Design
CBE 450	X	x		X	Capstone Process Design
CBE 470	x	X	X	x	Process Control

Course contributions are indicated with X (major) and x (minor). The Chemical Engineering

Electives and Professional Breadth Electives provide additional opportunities for specialized applications of engineering background in selected areas of interest chosen by each student.

Hazards are associated with processes in many areas of chemical engineering interest. When topics are introduced in different courses the relevant potential hazards can be described to create a strong linkage between new technologies and potential operating problems associated with those technologies. An inventory of process hazard coverage across the curriculum identified many modules that discuss potential for accidents or cover historical accidents related to the unit operations under discussion. Coverage of particular topics, management systems, and regulatory frameworks in project courses varies depending on the process under study that semester. In consideration of the broad range of industries and career paths followed by our graduates, the program has chosen to continue and even enhance this distributed or integrated treatment of process hazards rather than collecting discussion and management of process hazards into a single, standard course.

The detailed curriculum with specifics on course names, numbers, and credits has already been presented in Criterion 5 – Curriculum, and improvements and in updates addressing several of the aspects of the Program Criteria are also described in Section 4.C – Continuous Improvement. Syllabi of the required courses showing the topic coverage and emphasis are presented in Appendix A. Additional detail on any aspects of interest will be provided gladly at the visit or in advance if requested.

Appendix A – Faculty Vitae

Nicholas L. Abbott
Rafael Chavéz-Contreras
Eric Codner
Juan J. dePablo
James A. Dumesic
Mark R. Etzel
Michael D. Graham
Daniel J. Klingenberg
Thomas F. Kuech
David M. Lynn
Christos Maravelias
Manos Mavrikakis
Regina M. Murphy
Paul Nealey
Sean P. Palecek
Brian F. Pfleger
James B. Rawlings
Jennifer R. Reed
Thatcher W. Root
Eric V. Shusta
Ross E. Swaney
John Yin

NICHOLAS L. ABBOTT, John T. Sobota and Magdalen L. Sobota Professor

EDUCATION

1991-1993 Department of Chemistry, Harvard University.
Postdoctoral research with George M. Whitesides. Research involving topics in surface chemistry and molecular self-assembly.

1986-1991 Doctor of Philosophy in Chemical Engineering at the Massachusetts Institute of Technology.
Molecular-level treatment of interactions between proteins and polymers in phase-separated aqueous polymer systems using statistical-thermodynamic theories, small angle neutron scattering and equilibrium partitioning experiments. Thesis advisors: Daniel Blankschtein and T. Alan Hatton.

1982-1985 Bachelor of Engineering in Chemical Engineering at the University of Adelaide, Australia.

EMPLOYMENT

2009-present Department Chair, Department of Chemical and Biological Engineering, University of Wisconsin-Madison.

2005-2006 Guest Professor, Department of Materials, Eidgenössische Technische Hochschule (ETH), Zürich (12 months).

2001- John T. Sobota and Magdalen L. Sobota Professor, Department of Chemical and Biological Engineering, University of Wisconsin-Madison.

1998- Professor, Department of Chemical and Biological Engineering, University of Wisconsin, Madison.

1997-1998 Associate Professor, and Joe and Essie Smith Endowed Professor.
Department of Chemical Engineering and Materials Science, University of California, Davis.

1993-1997 Assistant Professor, Department of Chemical Engineering and Materials Science, University of California, Davis.

1986 Department of Biochemistry, University of Adelaide, Australia, for 10 months.

HONORS (not all shown)

2012 Jeanne and Martin Sussman Lectureship, Tufts University

2012 Plenary Lecture, International Conference on Nanoscience and Nanotechnology (Perth, Australia)

2011 Kurt Wohl Memorial Lecture, University of Delaware

2011 Plenary Lecture, 11^{th} European Conference on Liquid Crystals (Slovenia)

2011 Vilas Associate, University of Wisconsin-Madison

2011 AAAS Fellow

2010 Charles M.A. Stine Award of AIChE for Materials Research

2010 Technology Achievement Award, MIT Club of Wisconsin for Platypus Technologies LLC

CONSULTING AND PATENTS

Founder of Platypus Technologies LLC of Madison, WI.
37 Issued US Patents

SELECTED PUBLICATIONS (from 231 referenced publications)

Aytar, Burcu S; Muller, John P E; Golan, Sharon; Hata, Shinichi; Takahashi, Hiro; Kondo, Yukishige; Talmon, Yeshayahu; Abbott, Nicholas L; Lynn, David M., "Addition of ascorbic acid to the extracellular environment activates lipoplexes of a ferrocenyl lipid and promotes cell transfection", *Journal of Controlled Release: Official Journal of the Controlled Release Society*, 157(2), 249-59, 2012

Lowe, A.M..; Abbott, N.L.; "Liquid Crystalline Materials for Biological Applications", *Chemistry of Materials*, in press, **2012**.

Aytar, B.S.; Muller, J.E.E.; Kondo,Y.; Golan, S.; Talmon,Y.; Abbott, N.L.; Lynn, D.M. "Chemical Activation of Lipoplexes Prepared from DNA and a Ferrocenyl Lipid in the Presence of Cells using Ascorbic Acid", *Journal of Controlled Release*, in press, **2012**.

Guthrie, K.M.; Agarwal, A.; Tackes, D.S.; Johnson, K.W.; Abbott, N.L.; Murphy, C.J.; Czuprynski, C.J.; Kierski, P.R.; Schurr, M.J.; McAnulty, J.F. "Antibacterial Efficacy of Silver-Impregnated Polyelectrolyte Multilayers Immobilized on a Biological Dressing in a Murine Wound Infection Model.", *Annals of Surgery*, in press, **2012**.

Carlton, R.J.; Gupta, J.K.; Swift, C.L.; Abbott, N.L.; "Influence of Simple Electrolytes on the Orientational Ordering of Thermotropic Liquid Crystals at Aqueous Interfaces", *Langmuir*, 28(1), 31-36, **2012.**

Bai, Y., Abbott, N.L.,"Enantiomeric Interactions between Liquid Crystals and Organized Monolayers of Tyrosine-Containing Dipeptides", *Journal of American Chemical Society*, 134(1), 548-558, **2012**.

Abras, D.; Pranami, G.; Abbott, N.L., "The Mobilities of Micro- and Nano-Particles at Interfaces of Nematic Liquid Crystals", *Soft Matter*, 8, 2026-2035, **2012**.

Lin, I-H.;, Miller, D.S.; Bertics, P.J.; Murphy, C.J.; de Pablo, J.J.; Abbott, N.L.; "Endotoxin-Induced Structural Transformations in Liquid Crystalline Droplets", *Science*, 332(6035), 1297-1300, **2011**.

Pomerantz, W.C.; Yuwono, V.M.; Drake, R.; Hartgerink, J.D.; Abbott, N.L.; Gellman, S.H., "Lyotropic Liquid Crystals Formed from ACHC-Rich β-Peptides", *Journal of the American Chemical Society*, 133 (34), 13604-13613, **2011**.

Johnson, P.S.; Cook, P.L.; Liu, X.; Yang, W.; Bai,Y.; Abbott, N.L.; Himpsel, F.J. "Universal Mechanism for Breaking Amide Bonds by Radiation", *The Journal of Chemical Physics*, **135**, 044702, **2011**.

Tan, L.N.; Bertics, P.J.; Abbott, N.L., "Ordering Transitions in Nematic Liquid Crystals Induced by Vesicles Captured through Ligand-Receptor Interactions, *Langmuir*, 27(4), 1419-1429, **2011**.

RECENT PROFESSIONAL ACTIVITIES (not all shown)

2011- Chair-Elect of Gordon Research Conference on Liquid Crystals
2011- Co-editor of *Current Opinion of Colloid and Interface Science*.
2010- Executive Committee, International Liquid Crystal Society.
2010- Editorial Board of *Langmuir* (American Chemical Society).
2010- Editorial Board of *Chemistry of Materials* (American Chemical Society).
2009- Chairman, Department of Chemical and Biological Engineering, UW-Madison.
2008- Executive Member, Science Foundation Ireland, Principal Investigator Program.
2008- Co-Chairman, International Conference of Bionanotechnology, Dublin, Ireland.

RAFAEL CHAVEZ-CONTRERAS, Senior Lecturer

EDUCATION

1985	Ph.D. Chemical Engineering	University of Utah
1977	M.S. Chemical Engineering	ITESM, Monterrey, Mexico
1975	B.S. Industrial and Chemical Engineering	Instituto Tecnologico de Celaya, Celaya, Mexico

EMPLOYMENT

2010-present	Senior Lecturer, Department of Chemical and Biological Engineering, University of Wisconsin-Madison
2002-2010	Lecturer, Department of Chemical and Biological Engineering, University of Wisconsin-Madison
1999-2002	Visiting Professor, Department of Chemical Engineering, University of Wisconsin-Madison
1985-1999	Professor, Department of Chemical Engineering Instituto Tecnologico de Celaya, Celaya, Mexico
1978-1985	Professor Level B, Department of Chemical Engineering Instituto Tecnologico de Celaya, Celaya, Mexico
1976-1978	Professor Level A, Department of Chemical Engineering Instituto Tecnologico de Celaya, Celaya, Mexico

RECENT COURSES TAUGHT

CBE426. Mass Transfer Operations.
CBE424. Operations and Process Laboratory.
CBE326. Momentum and Heat Transfer Operations
CBE324. Transport Phenomena Laboratory.
CBE320. Introductory Transport Phenomena.
CBE311. Thermodynamics of Mixtures.
CBE250. Process Synthesis.
CBE211. Chemical Process Thermodynamics.

RECENT NON-CURRICULAR COURSES TAUGHT

Herramientas para la educación a distancia (Tools for Distance Education). January 2009, given during the XXV Seminar of Chemical Engineering at the Instituto Tecnológico de Celaya, Celaya Mexico. Course of 12 hours. The course was given to professors and instructors of several engineering disciplines, and consisted in an introduction to skills-based education using Moodle.

OTHER INDUSTRIAL EXPERIENCE

1979	Professor in residence, Univex (Chemical Company), Salamanca, Mexico.
1978	Campbell's Soup Company de Mexico, Ingredient Procurement Department, Villagran Mexico.
1974	Celanese Mexicana, Student Resident, Process Department, Celaya Mexico

MEMBERSHIPS

AIChE (American Institute of Chemical Engineers)
IMIQ (Mexican Institute Of Chemical Engineers)

AWARDS.

2006 Polygon Engineering Student Council Outstanding Instructor Award, Chemical and Biological Engineering.

INSTITUTIONAL AND PROFESSIONAL SERVICE

Chemical Engineering Area Chairman, Instituto Tecnologico de Celaya, 1978-1980. In charge of Graduate program startup.
Chairman, Department of Chemical Engineering, Instituto Tecnologico de Celaya, 1993-1996, and 1998-1999
Visiting Professor, Department of Chemical Engineering, Universidad de Tlaxcala, Mexico,1997-1998
Vicepresident, Mexican Institute of Chemical Engineers, Celaya Section (1998-1999)
Visiting Professor, Department of Chemical Engineering, University of Wisconsin Madison, 1986-2002

RECENT RELEVANT SOFTWARE AND WEB PROJECTS DEVELOPED

Simulation Models based on COMSOL Multiphysics for CBE324
Java Applet for teaching distillation in CBE426 and CBE424
Javascript page for instructional use of the Jeopardy game in CBE324.
Web based plagiarism detection system for CBE324 and CBE424 Reports.
Web based instructor course evaluation system for CBE department
Drupal based portal for Chemical and Biological Engineering Department (early development). Included undergrad curriculum and a package arrival notification system for the research groups. (http://www2.che.wisc.edu)

PUBLICATIONS

Gonzalez-Alatorre, G, R. Chavez-Contreras, P. Garza, P. Canchola, E. Escamilla, J. Rocha, A. Estrada, F.J. Alvarado, "A Series of Experiments on Alkyl Urea Nitrosation Kinetics," *Chemical Educator*, **9,** 231-233, 2004.

Tiscareño, F., A. Gomez, A. Jiménez, and R. Chavez, "Multiplicity in the Solution of the Flash Equations," *Chem. Eng. Sci.,* **53,** (4) 671-677, 1998.

Pérez Cárdenas, R. J.., G. M. Martínez-González, R. Chávez-Contreras, F. Tiscareño-Lechuga, D. Cházaro-Senderos, "Ladrillo rojo y contaminación ambiental," C*iencia y Tecnología Guanajuato*, Abril-Junio pp 23-25, 1997 (In Spanish)

Chavez, R., Seader, J.D. and Wayburn, T.L., 1986. Multiple steady-state solutions for interlinked separation systems. *Industrial Engineering and Chemistry Fundamentals* **25**, pp. 566–576.

ERIC CODNER, Instructor

EDUCATION

2001-04 Postdoctoral Fellow, University of Wisconsin – Madison
Chemistry Department
Research focus: Surface Plasmon Resonance instrumentation

2001 Ph.D., Analytical and Material Chemistry, University of Minnesota, Minneapolis, MN

1996 B.S. in Chemistry, University of Minnesota, Minneapolis, MN

1994 B.S. in Biochemistry, University of Minnesota, Minneapolis, MN

ACADEMIC EMPLOYMENT

2006- Instructor, University of Wisconsin – Madison
Department of Chemical and Biological Engineering

2005-06 Adjunct Professor, Metro State University, St. Paul, MN
Chemistry

2004-05 Project Scientist, University of California, Irvine
Biomedical Engineering Department
Research focus: MEMS vacuum electron devices

RECENT COURSES

CBE 324 Transport Phenomena Laboratory

CBE 424 Operations and Process Laboratory

CBE 575 Instrumentation for Chemical Engineers

CBE 599 Undergraduate Research (see research activities below)

NON-ACADEMIC EXPERIENCE

2006- Editor, Write Science Right, Inc.

2001- Consultant, Instrumentation and Manufacturing Process Design
Research Hardware LLC

HONORS / AWARDS

1998 NSF CIE Fellowship

1994 Minnesota Chromatography Forum Undergraduate Research Grant

1991 Undergraduate Research Grant – University of Minnesota

PATENTS AND PUBLICATIONS

2012 Guzei, I. A.; Spencer, L. C.; Codner, E; Boehm, J. M. 5′,11′-Dihydrodispiro [cyclohexane-1,6′-indolo[3,2-β]carbazole-12′,1″-cyclohexane]. Acta Cryst E (2012), E68, o1-o2

2005 Reddy, B.; Codner, E.; Tang, W. C.; MEMS Based Design for a Field Emission Electric Propulsion Micro-thruster. (declassified for submission to IEEE Journal of Microelectromechanical Systems)

2004 Corn, R. M.; Lee, H. J.; Wegner, G. J.; Smith, E. A.; Goodrich, T. T.; Codner, E. SPR imaging measurements for the rapid microarray detection of nucleic acids and proteins. Abstracts of papers, 225th ACS National Meeting, New Orleans, LA, USA, March 23-27, 2003

2004 Horizontal Surface Plasmon Resonance Instrument with Improved Light Path (U. S. patent #7,265,844)

2004 Portable Surface Plasmon Resonance Imaging Instrument (U. S. patent #7,148,968)

2004 Wegner, G. J.; Wark, A. W.; Lee, H. J.; Codner, E.; Saeki, T; Fang, S.; Corn, R. M. Real-Time Surface Plasmon Resonance Imaging Measurements for the Multiplexed Determination of Protein Adsorption/Desorption Kinetics and Surface Enzymatic Reactions on Peptide Microarrays. Analytical Chemistry (2004), 76(19), 5677-5684

2001 Simultaneous spectroscopic and adhesion measurements with a tandem IR-JKR instrument. Ph.D thesis

PRESENTATIONS

2011 "I thought PTFE tape was optional:" Teaching practical engineering skills in the unit operations laboratory. 2011 AIChE National Meeting, October 16, 2011, Minneapolis, Minnesota.

1999 What Makes it Stick? Investigating Adhesion Phenomena using the Tandem IR-JKR Apparatus. University of Minnesota Center for Interfacial Engineering Annual Meeting, Minneapolis, Minnesota.

1995 Evaluation of Field Flow Fractionation in Pollen Analysis. Minnesota Chromatography Forum Annual Meeting, Minneapolis, Minnesota

CURRENT RESEARCH ACTIVITIES

Organic semiconductor growth
Infrared sensor design
MEMS fabrication

JUAN J. DE PABLO, Professor

EDUCATION

1990-92 Postdoctoral - Materials Science Institut fuer Polymere, ETH, Zurich
(**Advisor** U.W. Suter)

1990 PhD - Chemical Engineering University of California, Berkeley
(**Advisor** J.M. Prausnitz)

1985 BS - Chemical Engineering National University of Mexico, UNAM

APPOINTMENTS

Director, Materials Research Science and Engineering Center (MRSEC) 6/01 to present
Professor of Chemical Engineering, University of Wisconsin 7/97 to present
Associate Professor of Chemical Engineering, University of Wisconsin 7/96-6/97
Assistant Professor of Chemical Engineering, University of Wisconsin 9/92-6/96
Postdoctoral Fellow, Institute for Polymers, ETH, Zurich, Switzerland 8/90-8/92
Process Engineer, Mexican Petroleum Institute, Mexico City 7/84-8/85

EDITIONIAL BOARDS

Editorial Board, *Materials Science and Engineering Reports*, 2008-2012
Editorial Board, *Journal of Physics –Condensed Matter*, 2007-2012
Associate Editor, *Physical Review Letters*, 2007-2012

AWARDS (not all shown)

2011 The Julian C. Smith Lectures, Cornell University
2011 Oersted Award, Danish technical University (DTU), Lingby, Denmark
2011 Elected into American Academy of Arts and Sciences
2011 Styne Award in Materials Research, American Institute of Chemical Engineers
2010 Byron Bird Award for Excellence in a Technical Publication
2010 The Harry Fair Lecture, University of Oklahoma
2010 The Trotter Lectures, University of Tennessee
2008 Chevron Phillips Lecture, Iowa State University
2008 Stanley Corrsin Memorial Lecture in Fluid Mechanics, Johns Hopkins University
2008 Eli Burstein Lecture, University of Pennsylvania
2006 University Lecture, University of California, Riverside
2005 Merck Distinguished Collaboratus Lecture, Rutgers University
2004 Dow Lecture in Materials Science, Northwestern University
2004 Elected Fellow, American Physical Society
2002 Paul Flory Lectures in Physical and Macromolecular Chemistry - Stanford University
2002 Samuel C. Johnson Distinguished Fellowship
2000 Wohl Memorial Lecture in Chemical Engineering - University of Delaware
1998 Howard Curler Distinguished Chair in Chemical Engineering
1997 Camille Dreyfus Teacher-Scholar Award
1996 Presidential Early Career Award in Science and Engineering from the National Science Foundation & Presidential Faculty Fellow (PFF) Award from President W. Clinton
1995 Polygon Engineering Council Outstanding Instructor Award

Professor de Pablo is the author of over 350 publications in peer reviewed journals, which have collectively received over 10,000 citations and reached a citation index (HI) of 54.

RECENT PUBLICATIONS (not all listed)

1. Liu, G., Ramirez-Hernandez A., de Pablo J.J., and Nealey, P.F., "*Symmetric Diblock Copolymers Confined Between Two Nanopatterned Substrates*," Phys. Rev. Lett., **108**, 065502, 2012.
2. Moreno-Razo J. A.; Sambriski E. J.; Abbott N. L. and J.J. de Pablo, "*Liquid-crystal-mediated self-assembly at nanodroplet interfaces,*" Nature, **485**, 86-89 (2012)
3. Detcheverry F.A., Pike D.Q., Nealey P.F., M. Mueller,and de Pablo, J.J., "*Simulations of theoretically informed coarse grain models of polymeric systems*," Faraday Discussions, **144**, 111-125 (2010)
4. D. Pike, F.A. Detcheverry, M. Mueller, P.F. Nealey and J.J. de Pablo, "*Monte Carlo Simulation of Coarse Grain Polymeric Systems,*" Phys. Rev. Lett. **102**, 197801 (2009).
5. H. Kang, F. Detcheverry, A. Mangham, P. Nealey, M. Mueller and J.J. de Pablo, "*Hierarchical assembly of nanoparticle superstructures from block copolymer-nanoparticle composites*," Phys. Rev. Lett., **100**, Art.No. 148303, (2008)
6. Middleton C. T.; Marek P.; Cao P., Skinner, J., de Pablo, J.J. and M. Zanni, "*Two-dimensional infrared spectroscopy reveals the complex behaviour of an amyloid fibril inhibito*r," Nature Chemistry, **4**, 355-360 (2012)
7. H. Kang, F.A. Detcheverry, E. Dobisz, D.S. Kercher, R.Ruiz, T.R. Albrecht, J.J. de Pablo and P.F. Nealey, "*Density Multiplication and Improved Lithography by Directed Block Copolymer Assembly,*" Science, **321**, 936-939, (2008).

SELECTED RECENT INVITED AND KEYNOTE LECTURES

Gordon Conference on Polymer Chemistry, 2011, Society of Rheology National Meeting, 2011, American Physical Society National Meeting, 2011, American Chemical Society National Meeting, Chicago, 2011, Gordon Conference on Biointerfaces, Les Diablerets, Switzerland, 2010, Gordon Conference in Polymer Physics, Mt. Holyoke, 2010, Gordon Conference in Computational Chemistry, Mt.Holyoke, 2008, Materials Research Society National Meeting, Boston, 2007, European Congress of Chemical Engineering, Lingby, Denmark, 2007.

Select Synergistic/Professional and Service Activities:

Mathematical and Physical Sciences Advisory Committee, National Science Foundation
National Research Council, Physics and Astrophysics Advisory Board
Department of Energy, Basic Energy Sciences, Visiting Committee
National Science Foundation, Chemical and Transport Systems, Committee of Visitors
National Science Foundation, Division of Materials Research, Committee of Visitors
National Science Foundation, Division of Chemistry, Committee of Visitors
National Science Foundation, Office of International Activities, Committee of Visitors
Advisory Boards of ETH-Zurich Materials Institute, Cornell University, Rensselaer Polytechnic Institute NSEC, Columbia University MRSEC, University of Massachusetts, NIH Center on Membrane Nanochannels, UIUC, Urbana.

JAMES A. DUMESIC, Steenbock Professor, Department of Chemical Engineering

EDUCATION

1974	Ph.D. Chemical Engineering Stanford University
1972	M.S., Chemical Engineering Stanford University
1971	B.S., Chemical Engineering University of Wisconsin

EMPLOYMENT

1996 - present	Steenbock Professor, Chemical Engineering Department, University of Wisconsin (UW) – Madison
1998 - 2000	Chair, Chemical Engineering Department, UW – Madison
1989 - 1996	Milton and Maude Shoemaker Professor, UW – Madison
1993 - 1995	Chair, Chemical Engineering Department, UW – Madison
1992 -1992	Acting Chair, Chemical Engineering Department, UW – Madison
1989 - 1992	Associate Chair, Chemical Engineering Department, UW – Madison
1982 - 1988	Professor, Chemical Engineering, UW – Madison
1979 - 1982	Associate Professor, Chemical Engineering, UW – Madison
1976 - 1979	Assistant Professor, Chemical Engineering, UW – Madison

SOCIETY MEMBERSHIPS

American Institute of Chemical Engineers
American Chemical Society
North American Catalysis Society

CONSULTING AND PATENTS

Haldor Topsøe Research Laboratories, Method for Catalytically Reducing Carboxylic Acid Groups to Hydroxyl Groups in Hydroxycarboxylic Acids, U. S. Patent filed, with R. D. Cortright.

Catalyst to Dehydrogenate Paraffin Hydrocarbons, U. S. Patent 5,736,478 (1998), with R. D. Cortright.

Low temperature hydrogen production from oxygenated hydrocarbons, U.S. Patent Application (P01411US), with R.D. Cortright

Low temperature hydrocarbon production from oxygenated hydrocarbons, U.S. Patent 6,699,457 B2 (2004), with R.D. Cortright

Catalytic Method to Remove CO and Utilize Its Energy Content in CO-Containing Streams, U. S. Patent P04360US filed, with Won Bae Kim, G. J. Rodriguez-Rivera, and T. Voitl

RECENT AWARDS AND HONORS (Not all shown)

2012 - George A. Olah Award in Hydrocarbon or Petroleum Chemistry, American Chemical Society

2011 - Michel Boudart Award, North American Catalysis Society and European Federation of Catalysis Societies

2011 - Wisconsin Alumni Research Foundation (WARF) Named Professorship

2010 - Doraiswamy Lectureship, National Chemical Laboratory, Pune, India.

2010 - Eastman Lectures, University of California - Berkeley and EBI

2010 - Basore Distinguished Lectureship - Auburn University

2010 - Distinguished Achievement Award, International Precious Metals Inst.

2010 - Plenary lecture at 14th Nordic Catalysis Symposium, Denmark

2010 - Plenary lecture at TCS 2010 Symposium on Thermal and Catalytic Sciences for Biofuels and Biobased Products, Ames, Iowa
2010 - The Top 100 People in Bio-energy; Biofuels Digest
2009 - American Academy of Arts and Sciences
2009 - Debye Lecture, Utrecht University, The Netherlands
2009 - William H. Walker Award of AIChE
2008 - Heinemann Award, International Federation of Catalysis Societies

RECENT PUBLICATIONS (from 370 total*)*

Selective hydrogenolysis of polyols and cyclic ethers over bifunctional surface sites on rhodium-rhenium catalysts, *Journal of the American Chemical Society* 133, 12675 (2011), Mei Chia, Yomaira J. Pagán-Torres, David Hibbitts, Qiaohua Tan, Hien N. Pham, Abhaya K. Datye, Matthew Neurock, Robert J. Davis, and J. A. Dumesic.

Integrated catalytic system to convert γ-valerolactone to liquid alkenes for transportation fuels, *Science* 327, 1110 (2010), J. Q. Bond, D. Martin-Alonso, R. M. West, D. Wang and J. A. Dumesic.

Inter-conversion between γ-valerolactone and pentenoic acid combined with decarboxylation to form butene over silica/alumina, *Journal of Catalysis* 281, 290 (2011), Jesse Q. Bond, Dong Wang, David Martin Alonso, and J. A. Dumesic.

Production of Biofuels from Cellulose and Corn Stover Using Alkylphenol Solvents, *Chemistry and Sustainability* 4, 1078 (2011), David Martin Alonso, Stephanie G. Wettstein, Jesse Q. Bond, Thatcher W. Root and James A. Dumesic.

Production of liquid hydrocarbon fuels by catalytic conversion of biomass-derived levulinic acid, *Green Chemistry* 7, 1755 (2011), Drew J. Braden, Carlos A. Henao, Jacob Heltzel, Christos C. Maravelias and James A. Dumesic.

Liquid-phase catalytic transfer hydrogenation and cyclization of levulinic acid and its esters to γ-valerolactone over metal oxide catalysts, *Chemical Communications* 47(44), 12233 (2011), Mei Chia and James A. Dumesic.

Synthesis of highly ordered hydrothermally stable mesoporous niobia catalysts by atomic layer deposition, *ACS Catalysis* 1, 1234 (2011), Yomaira J. Pagán-Torres, Jean Marcel R. Gallo, Dong Wang, Hien N. Pham, Joseph A. Libera, Christopher L. Marshall, Jeffrey W. Elam, Abhaya K. Datye, and James A. Dumesic.

PhD Advisor: Michel Boudart; Postdoctoral Advisor: Albert Cassuto
Recent Ph.D. graduates and postdocs* from the group:

Yomaira Pagan	September 2011	Dow Chemical
Mark Tucker	June 2011	BP
Jesse Bond*	July 2011	Syracuse University
Drew Braden	August 2010	BP
Juan Carlos Serrano-Ruiz*	October 2009	University of Córdoba
Ed Kunkes	August 2009	Fritz Haber Institute
Ryan West	June 2009	Proctor and Gamble
Chris Barrett	August 2008	General Foods
Yuriy Roman-Leshkov	August 2008	MIT
Dante Simonetti	July 2008	UOP

MARK R. ETZEL, Professor

EDUCATION

1983 Ph.D. Chemical Engineering, University of California at Berkeley

1977 B.S. Chemical Engineering, Purdue University (Honors)

EMPLOYMENT

1989 – present University of Wisconsin, Madison, Wisconsin

Professor, Department of Food Science, Department of Chemical and Biological Engineering (by courtesy), Department of Biological Systems Engineering (by courtesy), Center for Dairy Research (by courtesy). Research in food and bioprocess engineering: mass transfer and bioseparation processes, membrane bioseparations, protein purification, drying of foods and microorganisms.

1983-1989 Polaroid Corporation, Cambridge, Massachusetts, 9/83 to 3/89, Senior Scientist.

PATENTS (selected, last 5 years)

Etzel, MR, Helm, TR, Vyas HK, "Methods Involving Whey Protein Isolates," US Patent 8,071,152, December 6, 2011.

Etzel MR, Yi H, Helimann SM, Rasmussen JK, Seshadri K, Shannon SK, Waller Jr CP, Weiss DE, "Ligand Functionalized Substrates," U.S. Pat Applic. 20110184078, July 28, 2011.

Etzel MR, Root T, Arunkumar A, Gemili S, "Methods and Compositions Involving Whey Protein Isolates, U.S. Pat Applic., 20120029165, February 2, 2011

Ney DM, Etzel MR, "Glycomacropeptide Medical Foods for Nutritional Management of Phenylketonuria and Other Metabolic Disorders, U.S. Pat. Applic. 20100317597, December 16, 2010.

Cook ME, Yang M, Etzel MR, "Methods for Heat-Stabilizing Proteins with Specific Binding Activities, U.S. Pat. 7,750,117, July 6, 2010.

Etzel MR, Seshadri K, Rasmussen JK, Waller Jr CP, Weiss DE, He Y, "Ligand Functionalized Substrates," U.S. Pat Applic. 20100075131, March 25, 2010.

Etzel, MR, Helm, TR, Vyas HK, "Methods Involving Whey Protein Isolates," US Patent 7,378,123, May 27, 2008.

Etzel M, "Adsorptive Membranes for Trapping Viruses," Patent Application US2008/0014625 A1, January 17, 2008.

PUBLICATIONS (selected, last 5 years)

Bund T, Allelein S, Arunkumar A, Lucey JA, Etzel MR, "Chromatographic Purification and Characterization of Whey Protein-Dextran Glycation Products," J. Chromat. A, (submitted).

van Calcar SC, Macleod EL, Gleason ST, Etzel MR, Rice GM, Ney DM, "Glycomacropeptide (GMP): A New Option for PKU Diet Management," Molec. Genetics Metabol., 102(3):262 (2011).

Etzel MR, Bund, T, "Monoliths for the Purification of Whey Protein-Dextran Conjugates," J. Chromat. A, 1218(17): 2445-2450 (2011).

Riordan WT, Brorson K, Lute S, Etzel MR, "Examination of the Adsorption of Large Biological Molecules to Anion Exchange Surfaces using Surface Plasmon Resonance," Sep. Sci. Technol., 45(1):1-10, (2010).

LaClair CE, Etzel MR, "Ingredients and pH are Key to Clear Beverages that Contain Whey Protein," J. Food Sci., 75(1):C21-C27 (2010).
LaClair CE, Etzel MR, "Turbidity and Protein Aggregation in Whey Protein Beverages," J. Food Sci. 74(7): C526-C535 (2009).
Riordan WT, Heilmann SM, Brorson K, Seshadri K, Etzel MR, "Salt Tolerant Membrane Adsorbers for Robust Impurity Clearance," Biotechnol. Prog. 25(6): 1695-1702 (2009).
Bhushan S, Etzel MR, "Charged Ultrafiltration Membranes Increase the Selectivity of Whey Protein Separations," J. Food Sci., 74(3):E131-9, 2009.
Riordan WT, Heilmann SM, Brorson K, Seshadri K, He Y, Etzel MR, "Design of Salt Tolerant Membrane Adsorbers for Viral Clearance," Biotechnol. Bioeng., 103(5):920-9, 2009.
LaClair CE, Etzel MR, "Purification and Use of Glycomacropeptide for Nutritional Management of Phenylketonuria," J. Food Sci., 74(4):E199-E206, 2009.
Etzel MR, "Charged Ultrafiltration and Microfiltration Membranes in Antibody Purification," in "Process Scale Purification of Antibodies," Gottschalk U, Editor, John Wiley & Sons, Hoboken, NJ, (2009).
Ney DM, Gleason ST, van Calcar SC, MacLeod EL, Nelson KL, Etzel MR, Rice GM, Wolff JA, "Nutritional Management of PKU with Glycomacropeptide from Cheese Whey," J. Inherit. Metab. Dis., 32(1):32-9, 2009.
van Calcar SC, MacLeod EL, Gleason ST, Etzel MR, Clayton MK, Wolff JA, Ney DM, "Improved Nutritional Management of Phenylketonuria Using a Diet Containing Glycomacropeptide Compared with Amino Acids," Am. J. Clin. Nutr., 89(4):1068-77, 2009.
Etzel MR, Riordan WT, "Viral Clearance Using Monoliths," J. Chromat. A, 1216(13):2621-4, 2009.
Ney DM, Hull AK, van Calcar SC, Liu XW, Etzel MR, "Dietary Glycomacropeptide Supports Growth and Reduces the Concentrations of Phenylalanine in Plasma and Brain in a Murine Model of Phenylketonuria," J. Nutr. 138(2): 316-322, 2008.
Lute S, Riordan W, Pease L, Tsai DH, Levy R, Sofer G, Haque M, Moroe I, Sato T, Morgan M, Krishnan M, Campbell J, Genest P, Dolan S, Meyer A, Zachariah M, Tarlov M, Etzel M, Brorson K, "A Consensus Rating Method for Small Virus-Retentive Filters. I. Method Development." PDA J. Pharm. Sci. Technol. 62(5): 318-333, 2008.
Ney DM, Hull AK, van Calcar SC, Liu XW, Etzel MR, "Dietary Glycomacropeptide (GMP) Supports Growth and Reduces the Concentrations of Phenylalanine in Plasma and Brain in the PKU Mouse," Molec. Genetics Metab. 93(3): 263-263, 2008.
Bhushan S, Etzel MR, "Charged Ultrafiltration Membranes for Protein Separation," Am. Soc. Agric. Biol. Engrs., Paper Number 077063, ASABE Annual International Meeting, Minneapolis, MN, 17-20 June 2007.
Etzel MR, Riordan WT, "Membrane Chromatography: Analysis of Breakthrough Curves and Viral Clearance." Ch. 9 in "Process Scale Bioseparations for the Biopharmaceutical Industry," Shukla A, Gadam S, and Etzel MR Editors, CRC Press, Tayor & Francis Group, Boca Raton, FL, 2007.
Etzel MR, "Bulk Protein Crystallization – Principles and Methods." Ch. 5 in "Process Scale Bioseparations for the Biopharmaceutical Industry," Shukla A, Gadam S, and Etzel MR Editors, CRC Press, Tayor & Francis Group, Boca Raton, FL, 2007.
Shukla A, Gadam S, Etzel MR Editors, "Process Scale Bioseparations for the Biopharmaceutical Industry," CRC Press, Tayor & Francis Group, Boca Raton, FL, 2007.

MICHAEL D. GRAHAM, Harvey D. Spangler Professor

EDUCATION

1992 Ph.D. -Chemical Engineering, Cornell University
1986 B.S. (magna cum laude) -Chemical Engineering, University of Dayton

APPOINTMENTS

2010-present	Professor (by courtesy), Department of Engineering Physics, University of Wisconsin-Madison
2007-present	Professor (by courtesy), Department of Mechanical Engineering, University of Wisconsin-Madison
2006-2009	Chair, Department of Chemical and Biological Engineering, University of Wisconsin-Madison
2004-present	Professor, Department of Chemical and Biological Engineering, University of Wisconsin-Madison
1999-2004	Associate Professor, Department of Chemical and Biological Engineering, University of Wisconsin-Madison
1994-1999	Assistant Professor, Department of Chemical and Biological Engineering, University of Wisconsin-Madison
1993	Princeton University (Postdoctoral Research Associate)
1992	University of Houston (Postdoctoral Research Associate)
1986-1991	Cornell University (Graduate Research Assistant, Chemical Engineering)
1990	Kernforschungszentrum Karlsruhe, Germany (DAAD fellow)
1987-1989	Cornell University (Teaching Assistant, Chemical Engineering)
1984-1986	University of Dayton Research Institute (Undergraduate Researcher)

OTHER CAMPUS AFFILIATIONS

2009-present	Trainer, Computation and Informatics in Biology and Medicine program.
2004-present	Member, Nanoscale Science and Engineering Center.
1994-present	Member, Rheology Research Center.

AWARDS, HONORS AND FELLOWSHIPS

Pearson Lecturer, UC-Santa Barbara, 2012.
Kellett Mid-Career Award, UW-Madison, 2012.
Fellow, American Physical Society, 2011
Invitee, National Academy of Engineering Frontiers of Engineering Symposium, 2008
Harvey D. Spangler Professorship, Dept. of Chemical and Biological Engineering, 2005
Francois Naftali Frenkiel Award for Fluid Mechanics, American Physical Society, 2004
Allan P. Colburn Memorial Lecturer, Univ. of Delaware, 2005.
Vilas Associate in the Physical Sciences, UW-Madison, 2002-2004
3M Non-Tenured Faculty Award, 1997-1999
NSF CAREER Award, 1995-1999
Shell Faculty Fellow, 1994-1997
DAAD (German Academic Exchange Service) scholarship for research in Germany, 1990
Outstanding Graduate Teaching Assistant, Cornell University, 1987-88
McMullen Graduate Fellowship, Cornell University, 1986-87

1st Place, AIChE Environmental Division Undergraduate Student Paper Competition, 1986

CONSULTING
ORBITEC, 2008-2009.
Value Recovery Inc., 2001-2003.
Fish and Richardson P. C., 2001.

EDITORIAL, REVIEW AND ADVISORY SERVICE (selected)
Board of Judges, Kirkpatrick Award (Chemical Engineering magazine) 2009
Associate Editor, Journal of Fluid Mechanics, 2005-.Present
Editorial Board, Journal of Non-Newtonian Fluid Mechanics, 2004-Present.
Advisory Council, Department of Chemical and Materials Engineering, University of Dayton, 2004-.Present
National Research Council / US National Committee on Theoretical and Applied Mechanics, Society of Rheology Representative, 2004-2008.

SELECTED PUBLICATIONS (from ~110 total)
Kumar, A. and Graham, M. D., "Margination and segregation in confined flows of blood and other multicomponent suspensions", submitted (2012).
Wang, J., Tozzi, E. J., Graham, M. D. and Klingenberg, D. J., "Flipping, scooping, and spinning: Drift of rigid curved nonchiral fibers in simple shear flow", submitted (2012).
Kumar, A. and Graham, M. D., "Accelerated boundary integral method for multiphase flow in non-periodic geometries", submitted (2011).
Pranay, P., Henriquez Rivera, R. G. and Graham, M. D., "Depletion layer formation in suspensions of elastic capsules in Newtonian and viscoelastic fluids", Phys. Fluids, to appear (2012).
Xi, L., and Graham, M. D., "Intermittent dynamics of turbulence hibernation in Newtonian and viscoelastic minimal channel flows", J. Fluid Mech., 693, 433472 (2012).
Xi, L., and Graham, M. D., "Dynamics on the laminar-turbulent boundary and the origin of the maximum drag reduction asymptote", Phys. Rev. Lett. 108, 028301 (2012).
Zhang, Y., de Pablo, J. J. and Graham, M. D., "An immersed boundary method for Brownian dynamics simulation of polymer in complex geometries: Application to DNA flowing through a nanoslit with embedded nanopits", J. Chem. Phys., 36, 014901 (2012). Selected for Virtual Journal of Nanoscale Science and Technology and Virtual Journal of Biological Physics Research.
Kumar, A., and Graham, M. D., "Segregation by membrane rigidity in flowing binary suspensions of elastic capsules", Phys. Rev. E 84, 066316 (2011). Selected for Virtual Journal of Nanoscale Science and Technology.
Underhill, P. T. and Graham, M. D., "Correlations and fluctuations of stress and velocity in suspensions of swimming microorganisms", Phys. Fluids 23, 121902 (2011).
Tamamo, S., Graham, M. D. and Morinishi, Y., "Streamwise variation of turbulent dynamics in boundary layer flow of drag-reducing fluid", J. Fluid Mech. 686, 352-377 (2011).
Tamano, S., Graham, M. D. and Morinishi, Y., "Streamwise variations in turbulence statistics in drag-reducing turbulent boundary layer of viscoelastic fluids", Proceedings of ASME-JSME-KSME Joint Fluids Engineering Conference 2011 (2011).

DANIEL JOSEPH KLINGENBERG, Professor

EDUCATION

1990-1991 University of British Columbia, Vancouver, B.C, Postdoctoral Fellowship
1989-1991 University of Illinois, Urbana, IL, Ph.D. Chemical Engineering
1985-1989 University of Illinois, Urbana, IL, M.S. Chemical Engineering
1981-1985 University of Missouri, Rolla, MO, B.S. Chemical Engineering

RESEARCH AND WORK EXPERIENCE

2006-present Professor, Department of Chemical and Biological Engineering
2007 Visiting Scientist, General Motors Research & Development and Planning
1997-2006 Associate Professor, Department of Chemical and Biological Engineering
1991-1997 Assistant Professor, Department of Chemical Engineering
1994-1995, 2000-2001 Acting Chairman, Rheology Research Center Executive Committee
1996-present Associate Chairman, Rheology Research Center Executive Committee

MEMBERSHIPS

Society of Rheology

RECENT AWARDS

Polygon Outstanding Instructor Award, '92-93, '03-04, '04-05, '10-11, '11-12.
Benjamin Smith Reynolds Award for Excellence in Teaching Engineers, 2011.
Best Poster Award (student presenter: J. Samaniuk), Annual Society of Rheology meeting, Cleveland, OH, 2011.
Best Poster Award (student presenter: K. Allen), National Society of Black Engineers Fall Regional Conference, Milwaukee,WI, 2011.

RECENT SERVICE

Department of Chemical and Biological Engineering Curriculum Committee Chair
College of Engineering Curriculum Committee Chair
Society of Rheology, 2013 Annual Meeting Technical Program Chair
Missouri University of Science and Technology Advisory Council

RECENT PUBLICATIONS (since 2010)

Flipping, scooping, and spinning: Drift of rigid curved nonchiral fibers in simple shear flow, J. Wang, E. J. Tozzi, M. D. Graham, and D. J. Klingenberg, submitted to Phys. Fluids (2012).

Rheological modification of corn stover biomass at high solids concentrations, J. R. Samaniuk, C. T. Scott, T. W. Root, and D. J. Klingenberg, J. Rheol., in press (2012).

A simulation study on the effects of shear flow on the microstructure and electrical properties of carbon nanotube/polymer composites A. E. Eken, E. J. Tozzi, D. J. Klingenberg and W. Bauhofer, Polymer, in press (2011).

Rheology and extrusion of high-solids biomass, C. T. Scott, J. R. Samaniuk and D. J. Klingenberg, TAPPI J., **10**, 47–53 (2011).

Rheology of concentrated biomass, J. R. Samaniuk, J. Wang, T. W. Root, C. T. Scott and D. J. Klingenberg, Korea-Australia Rheology Journal, **23**, 237–245 (2011).

Settling dynamics of asymmetric rigid fibers, E. J. Tozzi, C. T. Scott, D. Vahey and D. J. Klingenberg, Phys. Fluids, **23**, 033301 (2011).

A simulation study on the combined effects of nanotube properties and shear flow on the electrical percolation thresholds of carbon nanotube/polymer composites, A. E. Eken, E. J. Tozzi, D. J. Klingenberg and W. Bauhofer, J. Appl. Phys., **109**, 084342 (2011) .

Enhancing Magnetorheology, D. J. Klingenberg and J. C. Ulicny, Int. J. Mod. Phys. B., **25**, 911-917 (2011).

Magnetorheological fluids: A review, J. de Vicente, D. J. Klingenberg and R. Hidalgo-´Alvarez, Soft Matter, DOI: 10.1039/c0sm01221a (2011).

Steady shear magnetorheology of inverse ferrofluids, J. Ramos, D. J. Klingenberg, R. Hidalgo-´Alvarez and J. de Vicente, J. Rheol., **55**, 127–152 (2011).

The effect of high intensity mixing on the enzymatic hydrolysis of concentrated cellulose fiber suspensions, J. R. Samaniuk, C. T. Scott, T. W. Root and D. J. Klingenberg, Bioresource Technology, **102**, 4489-4494 (2011).

Shear-controlled electrical conductivity of carbon nanotubes networks suspended in low and high molecular weight liquids, W. Bauhofer, S. C. Schulz, A. E. Eken, E. J. Tozzi, D. J. Klingenberg, T. Skipa, D. Lellinger and I. Alig, Polymer, **51**, 5024–5027 (2010).

Enhancing magnetorheology with nonmagnetizable particles, J. C. Ulicny, K. S. Snavely, M. A. Golden and D. J. Klingenberg, Appl. Phys. Lett., **96**, 231903 (2010).

Effects of nonmagnetic interparticle forces on magnetorheological fluids, D. J. Klingenberg, C. H. Olk, M. A. Golden and J. C. Ulicny, J. Phys.: Cond. Matter, **22**, 324101 (2010).

*Rheology of dilute acid hydrolyzed corn stover at high solids concentration,*M. R. Ehrhardt, T. O. Monz, T. W. Root, R. K. Connelly, C. T. Scott, D. J. Klingenberg, Appl. Biochem. Biotechnol., **160**, 1102-1115 (2010).

INVITED PRESENTATIONS (since 2010)

Rheology and Mass Transfer of Lignocellulosic Biomass, , University of Tennessee-Knoxville , Department of Chemical and Biomolecular Engineering, April 24 (2012).

Rheology and Mass Transfer of Lignocellulosic Biomass, Northwestern University, Department of Chemical and Biological Engineering, October 27 (2011).

Rheology of Concentrated Biomass, International Symposium on Applied Rheology, Seoul, South Korea, May 27 (2011).

Rheology of Biomass, Shell Westhollow Technology Center, Houston, TX, March 17 (2011).

Enhancing Magnetorheology, Colorado School of Mines, Department of Chemical Engineering, October 8 (2010).

Rheology of Lignocellulosic Biomass, National Renewable Energy Laboratory, October 7 (2010).

EnhancingMagnetorheology, D. J. Klingenberg and J. C. Ulicny, The 12th International Conference on Electrorheological (ER) Fluids and Magnetorheological (MR) Suspensions, Philadelphia, PA, August 16-20 (2010).

Enhancing Magnetorheology, D. J. Klingenberg and J. C. Ulicny, 5th Pacific Rim Conference on Rheology, Hokkaido University, Sapporo, Japan, August 1-6 (2010).

PROFESSIONAL DEVELOPMENT ACTIVITIES

Writing textbook on Transport Phenomena with R. B. Bird and E. N. Lightfoot.

THOMAS F. KUECH, Milton J. and Maude Shoemaker, Professor of Chemical Engineering

EDUCATION

1981	Ph.D. (Applied Physics)	California Institute of Technology, Pasadena, CA.
1978	MS (Applied Physics)	California Institute of Technology, Pasadena, CA.
1978	MS (Materials Science)	Marquette University, Milwaukee, WI.
1976	BS (Physics)	Marquette University, Milwaukee, WI.

PROFESSIONAL CAREER

2011-	UW-Foundation Chair Beckwith-Bascom Professor, UW-Madison
2003-2006	Chair, Department of Chemical and Biological Engineering, UW-Madison
1997-	Shoemaker Professor of Chemical Engineering, UW-Madison
1996-2001	*Director*, Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces, UW-Madison
1992-1997	Professor of Chemical Engineering, UW-Madison
1990-1992	Associate Professor of Chemical Engineering, UW-Madison
1985-1990	Manager, Epitaxy of Compound Semiconductors, International Business Machines, Thomas J. Watson Research Center, Yorktown Heights, NY
1981-1985	Research Staff Member, International Business Machines, Yorktown Heights, NY 10598
1981	Research Fellow, California Institute of Technology, Pasadena, CA 91125

SOCIETY MEMBERSHIPS

American Association for Crystal Growth
American Chemical Society
American Institute of Chemical Engineers
American Physical Society
American Society for Engineering Education
American Vacuum Society
Böhmische Physicalishe Society
Electrochemical Society
IEEE
Materials Research Society

AWARDS AND HONORS (selected from past ten years)

UW-Foundation Chair Beckwith-Bascom Professorship, 2011-
Alexander von Humboldt Senior Research Award, 2011
National Academy of Engineering, 2010-
Fellow of the IEEE, 2010
Boelter University Lecturer, University of California, Los Angeles, 2010
Fellow, Institute for Advanced Studies, Hong Kong University of Science and Technology, Hong Kong, 2011-
Honorary Professor, Department of Physics, Nanjing University, Nanjing China, 2010.

UNIVERSITY SERVICE (selected from past five years)

- 2009-2010 Ad Hoc Committee to Determine the Needs and Structure of UW-Madison's Research Enterprise
- 2009 - University Honor Program committee
- 2009 Search committee for Campus Chemical Hygiene Officer
- 2008 Gradute School Dean Cadwallader review committee

PUBLISHED WORK AND PATENTS

Over 470 articles in refereed journals and conference proceedings; editor of two books; 20 book chapters or invited review articles in major journals; 19 patents issued and 11 published patent disclosures

PUBLICATIONS (selected from 475 total)

"The effect of helium ion implantation on the relaxation of strained InGaAs thin films",C.A. Paulson, S. Jha, X. Song, M. Rathi, S.E. Babcock, L. Mawst, T.F. Kuech, Thin Solid Films, 520 (2012) 2147-2154.

"Atomic Layer Deposition of Titanium Phosphate on Silica Nanoparticles", Monika K. Wiedmann, David H. K. Jackson, Yomaira J. Pagan-Torres, Eunkyung Cho, James A. Dumesic, and T. F. Kuech, J. Vacuum Sci. and Technology, 30 (2012) online.

"Hemin-Functionalized InAs-based High Sensitivity Room Temperature NO Gas Sensors", Aruna Dedigama, Michael Angelo, Pete Torrione, Tong Kim, Scott; Wolter, William Lampert, Ayomide Atewologun, Madhavie Edirisooriya, Leslie Collins, Thomas F. Kuech, Maria Losurdo, Giovanni Bruno, April Brown, J. of Physical Chemistry, to be published.

INVITED TALKS

Over 170 national and international invited talks and seminar presentations; over 500 contributed talks

SELECTED PROFESSIONAL ACTIVITIES (selected from past five years)

EDITORSHIPS:

- 2008- Editorial Board, Chemical Engineering Communications
- 2003- Principal Editor, Journal of Crystal Growth

PROFESSIONAL SOCIETY POSITIONS:

- 2011- Member, Commission on Crystal Growth and Characterization of Materials, International Union of Crystallography
- 2010 - Vice President of the International Organization for Crystal Growth
- 1998-2010 Secretary of the International Organization for Crystal Growth
- 2007-2010 Technical Program Committee, Strategic Program Planning Committee, Materials Research Society
- 2007 NAE Panel member evaluating the "The National Science Foundation's Materials Research Science and Engineering Center Program: Looking Back, Moving Forward" (http://books.nap.edu/catalog.php?record_id=11966).

PROFESSIONAL CONFERENCE LEADERSHIP:

- 1993- Advisory Board of the International Conference on Crystal Growth

DAVID MICHAEL LYNN, Associate Professor

EDUCATION & TRAINING

1999-2002 Postdoctoral Fellow MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge, MA
Advisor: Professor: Professor Robert Langer

1994-1999 Ph.D., Chemistry CALIFORNIA INSTITUTE OF TECHNOLOGY
Advisor: Professor Robert H. Grubbs
Dissertation Title: *Well-Defined, Water-Soluble Ruthenium Alkylidenes: Synthesis and Application to Olefin Metathesis in Protic Solvents.*

1990-1994 B.A., Chemistry, *Summa Cum Laude* UNIVERSITY OF SOUTH CAROLINA, Columbia, SC
Advisors: Professor John W. Baynes; Professor James M. Tour

PROFESSIONAL APPOINTMENTS

2008-Present, Associate Professor, Department of Chemistry (by courtesy); UW – Madison
2008-Present, Associate Professor, Department of Chemical and Biological Engineering; UW – Madison
2002-2008, Assistant Professor, Department of Chemistry (by courtesy); UW – Madison
2002-2008, Assistant Professor, Department of Chemical and Biological Engineering; UW – Madison
1999-2002 NIH Postdoctoral Fellow, Department of Chemical Engineering; MIT
1994-1999Graduate Research Assistant, Department of Chemistry; Caltech

ADDITIONAL PROFESSIONAL EXPERIENCE

1993 VIRGINIA POLYTECHNIC INSTITUTE & STATE UNIVERSITY, Blacksburg, VA
NSF Summer Undergraduate Research Program
Advisor: Professor Harry W. Gibson

PROFESSIONAL AFFILIATIONS

American Chemical Society (ACS); American Institute of Chemical Engineers (AIChE); Controlled Release Society (CRS); Materials Research Society (MRS); American Society of Gene and Cell Therapy (ASGCT)

TRAINING PROGRAMS & OTHER AFFILIATIONS – UNIVERSITY OF WISCONSIN–MADISON

2012-Present *Trainer,* NIH Vascular Surgery Training Program
2004-Present *Trainer*, NIH Biotechnology Training Program
2002-Present *Trainer*, NIH Chemistry-Biology Interface Training Program
2002-Present *Faculty*, Materials Science Program

HONORS & AWARDS (Not all shown)

2011 Edward C. Nagy New Investigator Award, National Institute of Biomedical Imaging & Bioengineering 2005 3M Corporation Non-Tenured Faculty Award
2010 Vilas Associate Award, University of Wisconsin – Madison
2010-Present Editorial Advisory Board, *Journal of Drug Delivery and Translational Research*
2008 Invited Participant, 2nd Transatlantic Symposium on the Frontiers of Chemistry
2007 Alfred P. Sloan Research Fellow, Alfred P. Sloan Foundation

2007 Kavli Frontiers Fellow, National Academy of Sciences
2007 Invited Participant, National Academy of Sciences 19th *Kavli Frontiers of Science* Symposium
2006 Invited Participant, 1st Transatlantic Symposium on the Frontiers of Chemistry

PUBLICATIONS (selected from past five years)

B. S. Aytar, J. P. E. Muller, S. Golan, S. Hata, H. Takahashi, Y. Kondo, Y. Talmon, N. L. Abbott, and D. M. Lynn, "Addition of Ascorbic Acid to the Extracellular Environment Activates Lipoplexes of a Ferrocenyl Lipid and Promotes Cell Transfection." *Journal of Controlled Release* **2012**, *157*, 249-259.

S. L. Bechler and D. M. Lynn, "Characterization of Degradable Polyelectrolyte Multilayers Fabricated Using DNA and a Fluorescently-Labeled Poly(b-amino ester): Shedding Light on the Role of the Cationic Polymer in Promoting Surface-Mediated Gene Delivery" *Biomacromolecules* **2012**, *13*, 542-552.

A. H. Broderick, M. R. Lockett, M. E. Buck, Y. Yuan, L. M. Smith, and D. M. Lynn, "*In situ* Synthesis of Oligonucleotide Arrays on Surfaces Coated with Crosslinked Polymer Multilayers." *Chemistry of Materials* **2012**, *24*, 938-945.

D. M. Lynn, "A 'Multilayered' Approach to the Delivery of DNA: Exploiting the Structure of Polyelectrolyte Multilayers to Promote Surface-Mediated Cell Transfection and Multi-Agent Delivery" in *Multilayer Thin Films, 2nd Edition* (G. Decher and J. Schlenoff, Eds.), Wiley-VCH, New York, **2012**, In press.

A. H. Broderick and D. M. Lynn, "Covalent Layer-by-Layer Assembly Using Reactive Polymers" In *Functional Polymers by Post-Polymerization Modification: Concepts, Practical Guidelines, and Applications* (P. Theato and H. A. Klok, Eds.), Wiley-VCH, New York, **2012**, In press.

S. L. Bechler and D. M. Lynn, "Reactive Polymer Multilayers Fabricated by Covalent Layer-by-Layer Assembly: 1,4-Conjugate Addition-Based Approaches to the Design of Functional Biointerfaces." *Biomacromolecules* **2012**, *13*, In press.

B. S. Aytar, M. R. Prausnitz, and D. M. Lynn, "Rapid Release of Plasmid DNA from Surfaces Coated with Polyelectrolyte Multilayers Promoted by the Application of Electrochemical Potentials." *ACS Applied Materials & Interfaces* **2012**, *4*, In press.

PATENTS & PATENT APPLICATIONS

29 US patents and patent applications

INVITED LECTURES AND PRESENTATIONS (selected from past year)

2011 January 9	Gordon Research Conference (GRC) on Macromolecular Materials Session on The Polymer-Biology Interface: Assembly and Delivery	Ventura, CA
2011 March 11	20 Years of Layer-by-Layer Assembly: New Frontiers for Fundamental Science and Applications	Strasbourg, France
2011 April 8	Polytechnic Institute of New York University (NYU-Poly) Department of Chemical Engineering	New York, NY
2011 April 12	National Institute of Biomedical Imaging and Bioengineering (NIBIB/NIH) Edward C. Nagy New Investigator Symposium	Bethesda, MD
2011 May 5	University of Michigan Department of Chemistry	Ann Arbor, MI

CHRISTOS T. MARAVELIAS, Associate Professor

EDUCATION

2004	CARNEGIE MELLON UNIVERSITY PhD in Chemical Engineering	PITTSBURGH, PA
1997	LONDON SCHOOL OF ECONOMICS M.Sc. in Operational Research	LONDON, UK
1996	NATIONAL TECHNICAL UNIVERSITY OF ATHENS Diploma in Chemical Engineering	ATHENS, GREECE

ACADEMIC EXPERIENCE

2004 – present UNIVERSITY OF WISCONSIN MADISON, WI

DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING

Associate Professor 2010 - present

Assistant Professor: 2004 – 2010

DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING

Faculty affiliate: 2009 – present

NON-ACADEMIC EXPERIENCE

02/04 – 06/04	SMARTOPS	PITTSBURG, PA
01/98 – 07/99	GREEK ARMY TELECOMMUNICATIONS DEVISION	ATHENS, GREECE

PROFESSIONAL ORGANIZATIONS

2006-Present, American Chemical Society (ACS)
2001-Present, American Institute of Chemical Engineers (AIChE)
2004-Present, Texas-Wisconsin-California Control Consortium (TWCCC)
2004-Present, Committee on Optimization and its Applications (COPTA) - University of Wisconsin
2002-Present, Institute for Operations Research and the Management Sciences (INFORMS)

HONORS AND AWARDS

2008 W. David Smith Jr. Graduate Student Paper Award – CAST Division of AIChE
2006-2011 National Science Foundation CAREER Award
2004-2007 Inaugural Olaf A. Hougen Fellowship
1999-2001 Alexander S. Onassis Public Benefit Foundation Graduate Fellowship
1999 Fulbright Graduate Fellowship (declined)

SERVICE

UNIVERSITY OF WISCONSIN - MADISON

Faculty Senator, 2004 - date
Graduate Admissions Committee, 2004 - 2011

PROFESSIONAL COMMITTEES:

Computing and Systems Technology (CAST) Division - American Institute of Chemical Engineers; Executive Committee – Ex-officio Member (2006 – 2009), Director (2012-14).
Emerging Areas Advisory Board, AIChE Journal; Member (2010 – date).

CONFERENCE ORGANIZATION:

Pan American Advanced Studies: Process Modeling and Optimization for Energy and Sustainability, 2012: Chair.

Process Systems Engineering 2009 & 2012: International Program Committee, Member.

European Symposium on Computer Aided Process Engineering 2011 & 2012, International Programme Committee, Member.

Foundations of Computer-aided Process Operations 2008 & 2012: Technical Advisory Committee, Member.

Foundations of Computer-aided Process Design 2009: Technical Advisory Committee, Member.

AIChE 2009 Annual Meeting: Area 10C Program Coordinator.

MANUSCRIPT REVIEWER:

AIChE Journal; Annals of OR; Applied Mathematical Modeling; Biotechnology Progress; Chemical Engineering Research and Design; Chemical Engineering and Processing; Chemical Engineering Science; Computational Management Science; Computers and Chemical Engineering; Computers and Industrial Engineering; Energy and Environmental Science; European Journal of Operational Research; IEEE-TransASE; IEEE-Transactions Engineering Management; Industrial and Engineering Chemistry Research; ISA Transactions; Metabolic Engineering; Naval Research Logistics; Operations Research.

SELECTED PUBLICATIONS

Maravelias, C. T. On the Combinatorial Structure of Discrete-time MIP Formulations for Chemical Production Scheduling. *Computers and Chemical Engineering*, 38, 204-212, **2012.**

Kim, J.; Reed, J.L.; **Maravelias, C. T.** Large-scale bi-level strain design approaches and mixed-integer programming solution techniques. *PLoS ONE*, 6(9), e24162, **2011**.

Kim, J.; Henao, C.A.; Johnson, T.A.; Dedrick, D.E.; Miller, J.A.; Stechel, E.B.; **Maravelias, C.T.** Methanol Production from CO_2 Using Solar-Thermal Energy: Process Development and Techno-Economic Analysis. *Energy and Environmental Science*, 4, 3122-3132, **2011**.

Colvin, M.; **Maravelias, C. T.** R&D Pipeline Planning: Task Interdependencies and Risk Management. *European Journal of Operational Research*, 215, 616-628, **2011**.

Braden, D.J.; Henao, C. A.; Heltzel, J.; **Maravelias, C.T.**; Dumesic, J.A. Production of Liquid Hydrocarbon Fuels by Catalytic Conversion of Biomass-derived Levulinic Acid. *Green Chemistry*, 13, 1755-1765, **2011**.

Henao, C. A.; **Maravelias, C. T.** Process Superstructure Optimization Using Surrogate Models. *AIChE J.*, 57(5), 1216-1232, **2011**.

Sundaramoorthy, A.; **Maravelias, C. T**. A General Framework for Process Scheduling. *AIChE J.*, 57(3), 695-710, **2011**.

SELECTED PRESENTATIONS

Keynote presentation: Rawlings, J.B.; Maravelias, C.T.; Subramanian, K.; Flores-Cerrillo, J.; Megan, L. Integration of Control Theory and Scheduling Methods for Supply Chain Management. *Foundations of Computer-aided Process Operations & Chemical Process Control*, Savannah, GA, January 8 – 11, **2012**.

CAST Plenary Session: Zenner, S.; Maravelias, C. T. Classification of chemical production scheduling problems and approaches, and a general solution framework. *AIChE Annual Meeting*, Minneapolis, MN, October 16-21, **2011**.

MANOS MAVRIKAKIS, Paul A. Elfers Professor

EDUCATION

University of Michigan, Ann Arbor, MI, Ph.D. in Chemical Engineering and Scientific Computing, 1994
University of Michigan, Ann Arbor, MI, MS in Applied Mathematics, 1993
University of Michigan, Ann Arbor, MI, MS in Chemical Engineering, 1989
National Technical University of Athens, Athens, Greece, Diploma in Chemical Engineering, 1988

APPOINTMENTS

Oct 2008-present Paul A. Elfers Professor, CBE Department, University of Wisconsin-Madison
Jun. 2007-Oct. 2008. Professor, CBE Department, University of Wisconsin-Madison,
May 2005-Jun 2007 Associate Professor, CBE Department, University of Wisconsin-Madison,
Oct .1999-May 2005 Assistant Professor, CBE Department, University of Wisconsin-Madison
May 1997-Sept 1999 Marie Curie Postdoctoral Fellow, Center for Atomic-scale Materials Physics, Department of Physics, Technical University of Denmark, Lyngby, Denmark.
May 1997-Aug. 1999 Visiting Research Scientist, Center for Catalytic Science and Technology (CCST), Department of Chemical Engineering, University of Delaware, Newark, DE.
Mar. 1996-May 1997 Postdoctoral Fellow, Center for Catalytic Science and Technology (CCST), Department of Chemical Engineering, University of Delaware, Newark, DE.
1994-1996 Military Naval Service, (obligatory): Programmer/Systems Analyst at the Center for Automation of Naval Combat Systems, Greece

COLLABORATORS AND OTHER AFFILIATIONS

Others than those listed as coauthors above: J. A. Dumesic (UW-Madison), T. F. Kuech (UW-Madison), M. Salmeron (LBL), F. Besenbacher (U of Aarhus, Denmark).

SELECTED HONORS AND AWARDS

2009 Paul H. Emmett Award in Fundamental Catalysis (North American Catalysis Society)
Top 100 Chemists for the 2000-2010 decade (Thomson-Reuters, Science Watch)
H.I. Romnes Faculty Fellow, UW-Madison, 2009.
Honored Instructor Award, UW-Madison, 2008.
Editorial Board of: *ACS Catalysis*, *Surface Science*, *Annual Reviews Chemical & Biomolecular Engineering*, *Catalysis Today*, *Journal of Molecular Catalysis A: Chemical*
NSF CAREER Award, 2002-2007.
Samuel C. Johnson & Son Distinguished Fellowship.
3M Non-tenured Faculty Award.
Shell Oil Company Foundation Faculty Career Initiation Award.
Visiting Professor, Technical University of Denmark, Department of Chemical Engineering (2006).
Visiting Professor, Center for Catalysis, Hokkaido University, Japan (2010).
NAE 2006 German-American Frontiers of Engineering Symposium (GAFOE), Murray Hill, NJ, May 2006.

Marie Curie Fellowship, 1997-1999, from European Science Foundation for Postdoctoral work at CAMP, DTU, Lyngby, Denmark.
Rackham Predoctoral Fellowship, 1992-1993, from Rackham School of Graduate Studies, U of Michigan.
Distinguished Achievement Award, 1992, College of Engineering, U of Michigan.
Outstanding Graduate Seminar Award, 1992, Chemical Engineering Department, U of Michigan.

SELECTED PUBLICATIONS (out of a total of ~120; h-factor=39, citations ~6,300)

Alkali-stabilized Pt-OH_x species catalyze low-temperature water gas shift reactions, Y. P. Zhai, D. Pierre, R. Si, W. L. Deng, P. Ferrin, A. U. Nilekar, G. W. Peng, J. A. Herron, D. C. Bell, H. Saltsburg, M. Mavrikakis, M. Flytzani-Stephanopoulos, Science 329, 1633 (2010).

2. Alloy Catalysts Designed from First-Principles**,** J. Greeley, M. Mavrikakis, Nature Materials, 3, 810 (2004).
3. Ru-Pt core-shell nanoparticles for preferential oxidation of CO in H_2, S. Alayoglu, B. Eichhorn, A. U. Nilekar, M. Mavrikakis, Nature Materials, 7**,** 333 (2008).
4. Computational Approaches: A search engine for catalysts, M. Mavrikakis, Nature Materials, 5**,** 847 (2006).
5. Controlling the Catalytic Activity of Platinum Monolayer Electrocatalysts for Oxygen Reduction with Different Substrates, J. Zhang, M.B. Vukmirovic, Y. Xu, M. Mavrikakis, R. R. Adzic, Angewandte Chemie International Edition, 44, 2132 (2005).
6. Mixed Metal Pt Monolayer Electrocatalysts for Enhanced Oxygen Reduction Kinetics, J. Zhang, M.B. Vukmirovic, K. Sasaki, A.U. Nilekar, M. Mavrikakis, R.R. Adzic, Journal of the American Chemical Society, 127, 12480 (2005).

SYNERGISTIC ACTIVITIES

Organized and chaired sessions/symposia at National AIChE, ACS, APS, AVS, and North American Catalysis Society meetings.
Reviewer for several journals and funding agencies.
Member of the Advising Board for (i) SUNCAT/ Photon Science SLAC National Accelerator Laboratory, Stanford, CA, (ii) DOE-EFRC: Center for Atomic-Level Catalyst Design, Baton Rouse, LA
IACT-EFRC: executive committee member

POSTDOCTORAL AND GRADUATE ADVISORS

Professors M. A. Barteau, J. L. Gland, J. K. Nørskov, and J. W. Schwank.

STUDENTS

Alumni: P. Ferrin (PhD ’09), R. Nabar (PhD ’09), R. West (PhD ’09), E. Kunkes (PhD ’09), L. Grabow (PhD ’08), A. U. Nilekar (PhD ’08), S. Kandoi (PhD ’06), A. A. Gokhale (PhD ’05), J. Greeley (PhD ’04), Y. Xu (PhD ’04), J. Schieke (MS ’02), F. Eichhorn (MS ’07), H. Stotz (MS ’10), J. Jiao (MS ’09), M-S. Han (Postdoc ’05), F. Mehmood (Postdoc ’07) *, Current Postdocs:* G. Peng, J. Scaranto, F. Celik, J. M. Gallo, *Current Graduate:* J. Herron, C. Farberow, T. Nason, S. Singh, Y. Bai, S. Li, R. Carrasquillo, A. Plauck, L. Roling, *Current Undergraduates:* W. Budiman, B. Foley.

REGINA M MURPHY, Smith Bascom Professor

EDUCATION
1989, Ph.D. Chemical Engineering, MIT
1978, B.S. Chemical Engineering, MIT

ACADEMIC EXPERIENCE

2002-Present,	Professor	University of Wisconsin
1995-2002,	Associate Professor	University of Wisconsin
1989-1995,	Assistant Professor	University of Wisconsin

NONACADEMIC EXPERIENCE
Designs Engineer, Process Engineer, Operations Assistant, Lead Engineer
Chevron USA   Richmond, CA   1978-1983

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS
American Institute for Medical and Biological Engineers, elected Fellow (2010)
American Chemical Society
American Institute of Chemical Engineers
Director, Food, Pharmaceutical and Bioengineering Division (2002-2005)

HONORS AND AWARDS
Vilas Associate Award, 2011-2013
Elected Fellow, American Institute of Medical and Biological Engineers, 2010
Smith-Bascom Chair in Chemical Engineering, 2008-2013
Chancellor's Distinguished Teaching Award, 2008
Johansen-Crosby Award Lecturer, Michigan State University, 2007
James G. Woodburn Award for Excellence in Teaching, 2006
Peck Lecturer, IIT, 2005
Harvey D. Spangler Chair in Chemical Engineering, 2000-2005
Romnes Faculty Fellow, 1999
Jordi Folch-Pi Award, American Society for Neurochemistry, 1998
S.E. Johnson Distinguished Fellowship, 1997
Alumni Teaching Quality Award, 1992
NSF Presidential Young Investigator Award, 1991-1996
Whitaker Health Sciences Fellow, 1988-1989

SERVICE ACTIVITIES (selected, 2007-2012)
External Review Panel, University of Notre Dame Chemical Engineering Department, February 2012
Biophysics Program Steering Committee, 2012-present
Athletic Board, 2012-present
Madison Initiative for Undergraduates Oversight Panel, 2010-2012
NSF Biotechnology, Biochemical, and Biomass Engineering Review Panel, 2010
External Review Panel, University of Illinois Chemical and Biological Engineering Department March 2009.

Chancellor Search and Screen Committee, 2008
Editorial Board, PEDS Protein Engineering, Design and & Selection (2007-present)
NIH Bioengineering Fellowship Review Panel, 2007
Physical Sciences Divisional Committee, 2006 – present.
Vice chair, 2007-2008, Chair, 2008-2009
NIH Biophysics of Neural Systems Study Section, Regular Member, 2006-2010
Executive Committee, Women's Faculty Mentoring Program, 2003-2008
NIH Biotechnology Training Grant Steering Committee, 2001-2012
Editorial Board, Biotechnology Progress (2000-present)
UW Biotechnology Center Faculty Advisory Committee, 2000-present.

RESEARCH PUBLICATIONS (2007-2012)

"Kinetics of Amyloid Formation and Membrane Interactions with Amyloidogenic Proteins". R. M. Murphy. *Biochim. Biophys. Acta.* 1768:1923-1934 (2007)

"Reconsidering the Mechanism of Polyglutamine Peptide Aggregation". C. C. Lee, R. H. Walters, and R. M. Murphy. *Biochemistry* 46: 12810-12820 (2007)

"Protein Misfolding and Aggregation: A Topical Review" R. M. Murphy and B. S. Kendrick. *Biotech. Prog.* 23:548-552, 2007

"A Strategy for Generating Polyglutamine 'Length Libraries' in Model Host Proteins." M. D. Tobelmann, R. L. Kerby, and R. M. Murphy. *Protein Eng. Des. Sel*. 21:161-164 (2008)

"Model Discrimination and Mechanistic Interpretation of Kinetic Data in Protein Aggregation Studies." J. P. Bernacki and R. M. Murphy. *Biophys. J*. 96: 2871-2887 (2009) [PMC2711288]

"Differential Modification of Cys10 Alters Transthyretin's Effect on Beta-Amyloid Aggregation and Toxicity". L. Liu, J. Hou, J. L.Du, R. S. Chumanov, Q. G. Xu, Y. Ge, J. A. Johnson and R. M. Murphy. *Prot. Eng. Des. Sel.* 22: 479-488 (2009) [PMC2719498]

"Examining Polyglutamine Peptide Length: A Connection between Collapsed Conformations and Increased Aggregation". R. H. Walters and R. M. Murphy *J. Mol. Biol.* 393: 978-992 (2009). [PMC2764006]

"Characterizing the Interaction of Beta-Amyloid with Transthyretin Monomers and Tetramers". J. Du and R. M. Murphy. Biochemistry 49: 8276-8289 (2010) [PMC2943652]

"Location Trumps Length: Polyglutamine-Mediated Changes in Folding and Aggregation of a Host Protein" M.D. Tobelmann and R. M. Murphy. *Biophysical J.* 100:2773-2782 (2011)

"Aggregation Kinetics of Interrupted Polyglutamine Peptides" R. H. Walters and R. M. Murphy, *J. Mol. Biol.* 412:505-519 (2011)

"Length-dependent Aggregation of Uninterrupted Polyalanine Peptides" J. P. Bernacki and R. M. Murphy. *Biochemistry* 50:9200-9211 (2011)

"When More is Not Better: Expanded Polyglutamine Domains in Neurodegenerative Disease". R. M. Murphy, R. H. Walters, M. D. Tobelmann, and J. P. Bernacki. *In* Non-fibrillar Amyloidogenic Protein Assemblies – Common Cytotoxins Underlying Degenerative Diseases, F. Rahimi and G. Bitan, editors. Springer Books. (2012)

TEXTBOOKS

Introduction to Chemical Processes: Principles, Analysis, Synthesis, R.M. Murphy. 2007, McGraw-Hill, Inc. 684 pp. In English, Spanish and Korean.

PAUL FRANKLIN NEALEY, Shoemaker Professor

PROFESSIONAL PREPARATION
1994-95, Postdoctoral, Harvard University
1994, Ph.D., Chemical Engineering, Massachusetts Institute of Technology
1985, B.S., Chemical Engineering (Magna Cum Laude), Rice University, Houston, Texas

APPOINTMENTS

2005-present	Professor of Chemical and Biological Engineering, UW-Madison
2004-present	Founding Director, NSF Nanoscale Science and Engineering Center on Templated Synthesis and Assembly at the Nanoscale
2004-present	Associate Director, UW Center for NanoTechnology
2001-present	Director, Semiconductor Research Corporation Advanced Lithography Network
2001-2005	Associate Professor of Chemical Engineering, UW-Madison
1995-2001	Assistant Professor of Chemical Engineering, UW-Madison
Fall 1991	Assistant Director, MIT School of Chemical Engineering Practice, Merck, Sharpe, and Dohme Station, West Point, Pennsylvania Engineer, Polypropylene Process Development, Solvay et Compagnie, Brussels, Belgium

COLLABORATORS & OTHER AFFILIATIONS
Albrecht, T. R., Black, C. T., Cao, H., Cerrina, F., de Pablo, J. J., Ferrier, N. J., Gobrect, J., Gopalan, P., Hamers, R. J., Himpsel, F. J., Jin, S., Kercher, D. S., Kuech, T. F., Mawst, L. J., Meagley, R. P., Melvin,
L. S., Müller, M., Murphy, C. J., Ruiz, R., Solak, H. H, Wendt, A. E., Char, K., van der Veen, J. F. **Graduate**

AWARDS AND HONORS (Not all shown)

2010	Member-at-Large, Division of Polymer Physics, American Physical Society
2009	Fellow – American Physical Society
2009	Semiconductor Research Corporation Inventor Recognition Awards
2007	Shoemaker Professor of Chemical and Biological Engineering
2007	NIST Polymer Division Distinguished Lecturer
2006	R&D Magazine Micro/Nano Top 25 Innovative Products of the Year
2005	Smith-Bascom Professor of Chemical and Biological Engineering
2005	American Chemical Society, PMSE Division, Arthur K. Doolittle Award
2005	University of Wisconsin Romnes Fellowship
2001	Camille Dreyfus Teacher-Scholar Award
2000-03	3M Non-Tenured Faculty Award
1997-2001	National Science Foundation Career Award

SELECTED PUBLICATIONS
Ruiz, R; Kang, H.M.; Detcheverry, F.A.; Dobisz, E; Kercher, D.S.; Albrecht, T.R.; de Pablo, J.J.; Nealey, P.F. "Density multiplication and improved lithography by directed block copolymer assembly". *Science* **321** (5891): 936-939 (2008).

Kang, H; Detcheverry, F.A.; Mangham, A.N.; Stoykovich, M.P.; Daoulas, K.C.; Hamers, R.J.; Muller, M; de Pablo, J.J.; Nealey, P.F.. "Hierarchical assembly of nanoparticle superstructures from block copolymer-nanoparticle composites". *Physical Review Letters* **100** (14): art. no.-148303 (2008).
Welander, A.M.; Kang, H.M.; Stuen, K.O.; Solak, H.H.; Muller, M; de Pablo, J.J.; Nealey, P.F. Rapid directed assembly of block copolymer films at elevated temperatures. *Macromolecules* **41** (8): 27592761 (2008).
Stoykovich, M.P.; Kang, H; Daoulas, K.C.; Liu, G; Liu, C.C.; de Pablo, J.J.; Mueller, M; Nealey, P.F.. "Directed self-assembly of block copolymers for nanolithography: Fabrication of isolated features and essential integrated circuit geometries". *ACS Nano* **1** (3): 168-175 (2007).
Liu, C.C.; Nealey, P.F.; Ting, Y.H.; Wendt, A.E. "Pattern transfer using poly(styrene-block-methyl methacrylate) copolymer films and reactive ion etching". *Journal of Vacuum Science & Technology B* **25** (6): 1963-1968 (2007).
Han, E.; Stuen, K. O.; Leolukman, M.; Liu, C.-C.; Nealey, P. F.; Gopalan, P., "Perpendicular orientation of domains in cylinder-forming block copolymer thick films by controlled interfacial interactions", *Macromolecules* **42** (13), 4896-4901 (2009).
Morin, S. A.; La, Y. H.; Liu, C.-C.; Streifer, J. A.; Hamers, R. J.; Nealey, P. F.; Jin, S., "Assembly of nanocrystal arrays via block copolymer directed nucleation", *Angewandte Chemie International Edition* **48** (12), 2135-2139 (2009).
Stuen, K. O.; Thomas, C. F.; Liu, G.; Ferrier, N. J.; Nealey, P. F., "Dimensional scaling of cylinders in thin films of block copolymer-homo-polymer ternary blends", *Macromolecules* **42** (14), 5139-5145 (2009).

SYNERGISTIC ACTIVITIES
Nanofabrication Techniques Based on Advanced Lithography and Directed Self-Assembly, Dimension Dependent Material Properties of Nanoscopic Macromolecular Structures, Development of Imaging Materials for Sub 50 nm Lithography, Effects of Biomimetic Nanostructured Surfaces on Cell Behavior

STUDENT ADVISOR AND POSTGRADUATE-SCHOLAR SPONSOR Graduate: Robert Cohen, Ali Argon; Postdoc: George Whitesides

GRADUATE STUDENT AND POSTDOCTORAL SPONSOR (Not all shown)
Current Graduate Students: Guoliang Liu, Ch-Chun Liu, Sean Delcambre, Elizabeth Tocce, Serdar Onses, Michelle Wilson, Bernardo Yanez-Soto, Paulina Rincon, Lance Williamson, Robert Seidel Current Postdoctoral Researchers/Research Scientists: Huiman Kang, Mikhail Efremov, Shengxiang Ji, Christopher Thode, Lei Wan, Sara Liliensiek
Former Students: Ph.D. Degrees: Susannah Clear (3M), David Fryer (Intel), Richard Peters (Motorola), Heidi Cao (Intel) Adam Pawloski (AMD), Ana Teixeira (Karolinska Institute-Sweden), Martha Montague (Intel), Nancy Karuri (Postdoc-Princeton University), Kenji Yoshimoto (Postdoc-UC-San Diego), Erik Edwards (Postdoc-Max Planck Institute-Berlin), Shuaigang Xiao (Seagate), Mark Stoykovich (Postdoc- University of Illinois, Faculty Position, University of Colorado), Teresa Porri (Cornell University), SangMin Park (IBM Almaden), Karl Stuen (Northwestern), Adam Welander (Proctor & Gamble)
M.S. Degrees: Marisol Franco, Euijun Kim (W.L. Gore), Hai Zhang, Maharshi Chauhan (Motorola), Sylvia Pasqualini (Intel),

SEAN P. PALECEK, Professor

EDUCATION

1998-2000	Postdoctoral Fellow, Department of Molecular Genetics and Cell Biology, Postdoctoral Advisor: Stephen J. Kron, University of Chicago
1998	Ph.D. Chemical Engineering; Thesis title: Regulation of Integrin-Mediated Linkages during Cell Migration, Thesis advisors: Douglas A. Lauffenburger and Alan F. Horwitz; Massachusetts Institute of Technology
1995	M.S. Chemical Engineering; Thesis title: Integrin Dynamics in the Tail Region of Migrating Fibroblasts, Thesis Advisors: Douglas A. Lauffenburger and Alan F. Horwitz; University of Illinois at Urbana-Champaign
1993	B.Ch.E. Chemical Engineering, Minor in Biology (with distinction); University of Delaware

POSITIONS AND EMPLOYMENT

2010-present	Professor, Department of Chemical & Biological Engineering, University of Wisconsin – Madison
2006-2010	Associate Professor, Department of Chemical & Biological Engineering, University of Wisconsin – Madison
2000-2006	Assistant Professor, Department of Chemical & Biological Engineering, University of Wisconsin-Madison

OTHER PROGRAM AFFILIATIONS

Executive Committee, Biotechnology Training Program
Affiliate, Department of Biomedical Engineering
Research Affiliate, WiCell Research Institute, Madison, WI
Member, Comprehensive Cancer Center
Trainer, Microbiology Doctoral Training Program
Trainer, Genomics Sciences Training Program
2005-present Trainer, Stem Cell Training Program
Executive Committee, Stem Cell and Regenerative Medicine Center

HONORS, AWARDS AND FELLOWSHIPS:

2012	Vilas Research Associate
2009	Circulation Research Best Paper of the Year
2009	American Heart Association Top Ten Advances in Heart Research
2004-2006	3M Nontenured Faculty Award
2003	NSF CAREER Award.
2001	Lilly Young Faculty Award in Biosystems Engineering

SERVICE ACTIVITIES

University of Wisconsin Physical Sciences Committee (Tenure and Promotions)
Chair, graduate admissions and recruiting committee
Teaching Assistant Coordinator

SELECT PUBLICATIONS

Metallo CM, Ji L, de Pablo JJ, **Palecek SP**. 2008. Retinoic acid and bone morphogenic protein signaling synergize to efficiently direct epithelial differentiation of human embryonic stem cells. *Stem Cells.* 26:372-380.

Zhang J, Wilson GF, Soerens AG, Koonce CH, Yu J, **Palecek SP**, Thomson JA, Kamp TJ. 2009. Functional cardiomyocytes derived from human induced pluripotent stem cells. *Circulation Research.* 104:e30-31.

Karlsson AJ, Pomerantz WC, Neilsen KJ, Gellman SH, **Palecek SP**. 2009. Effect of sequence and structural properties on 14-helical beta-peptide activity against Candida albicans planktonic cells and biofilms. *ACS Chemical Biology*. 4:567-579.

Azarin SM, Lian X, Larson EA, Popelka HM, de Pablo JJ, **Palecek SP**. 2012. Modulation of Wnt/b-catenin signaling in human embryonic stem cells using a 3-D microwell array. *Biomaterials*. 33:2041-2049.

Ghosh G, Lian X, Kron SJ, **Palecek SP**. 2012. Properties of resistant cells generated from lung cancer cell lines treated with EGFR inhibitors. *BMC Cancer*. 12:95.

Lee AG, Beebe DJ, Palecek SP. 2012. Quantification of kinase activity in cell lysates via photopatterned macroporous poly(ethylene glycol) hydrogel arrays in microfluidic channels. *Biomedical Microdevices*. 14:247-257.

Lian X, Hsiao C, Wilson GF, Zhu K, Hazeltine L, Azarin SM, Raval KK, Zhang J, Kamp TJ, **Palecek SP**. 2012. Robust cardiomyocyte differentiation from human pluripotent stem cells via temporal modulation of canonical Wnt signaling. *PNAS*. (in press).

Lippmann ES, Azarin SM, Kay JE, Nessler RA, Wilson HK, Al-Ahmad A, **Palecek SP**, Shusta EV. 2012. Human blood-brain barrier endothelial cells derived from pluripotent stem cells. *Nature Biotechnology*. (in press).

PROFESSIONAL DEVELOPMENT ACTIVITIES

Musculoskeletal Tissue Engineering Study Section, Permanent Member 2012-2016.

Panel for International Assessment of Stem Cell Engineering. Sponsored by NSF, NIH, NIST. 2011-2012. Workshop in May 2012. Report to be published as a book in 2012.

Chair, 3rd International Conference on Stem Cell Engineering sponsored by the Society for Biological Engineering and the International Society for Stem Cell Research. Seattle, WA. May 2012.

BRIAN F. PFLEGER, Assistant Professor

EDUCATION AND TRAINING

2005-2007	Chemical Biology	Postdoc, University of Michigan, Ann Arbor, MI
2000-2005	Chemical Engineering	PhD, University of California-Berkeley, Berkeley, CA
1996-2000	Chemical Engineering	BS, Cornell University, Ithaca, NY

PROFESSIONAL EXPERIENCE

2009-	Faculty Trainer	UW-Madison, Graduate Program in Cell and Molecular Biology
2008-	Faculty Trainer	UW-Madison, Microbiology Doctoral Training Program
2007-	Faculty Affiliate	UW-Madison, Dept. of Biomedical Engineering
2007-	Asst. Professor	UW-Madison, Dept. of Chemical and Biological Engineering
1999-2000	Co-op Engineer	3M Company, St. Paul, MN

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

American Institute of Chemical Engineers (AIChE)
Society of Industrial Microbiology (SIM)
American Chemical Society (ACS)
American Society of Microbiology (ASM)

AWARDS

2012	NSF CAREER Award
2011	Air Force Office of Scientific Research Young Investigator Award
2010	Polygon Engineering Council Outstanding Instructor Award
2010	3M Non-tenured Faculty Award
2006	Great Lakes RCE Postdoctoral Training Fellowship – Pfleger (PI)

DEPARTMENTAL AND CAMPUS SERVICE

2010-present	Member of Chemistry-Biology Interface Training Program Steering Committee
2009-present	Member of Graduate Admissions Committee
2007-present	Faculty Senator
2007-present	Served on 29 Preliminary Exam and 17 Thesis Defense Committees
2007-present	Chemical and Biological Engineering Seminar Coordinator
2010	3M-UW Partnership Technology Exchange
2008-2011	Departmental Recruiter for Engineering Department Fair
2007-2010	Advisor to Local AICHE Chapter
2007-2010	Liaison to Miller-Coors
2007-2010	Member of Great Lakes Bioenergy Research Center, Area 3 leadership council

NATIONAL SOCIETY AND COMMUNITY SERVICE

2011-present	Society of Industrial Microbiology Metabolic Engineering Subcommittee
2011-2012	SIM Annual Meeting Session Chair
2011	Biochemical Engineering XVII Session Chair
2009-2012,	AICHE Annual Meeting Session Chair
2009	ACS Annual Meeting Session Chair

GOVERNMENTAL PANEL SERVICE

2012 NAE - 2012 Indo-American Frontiers of Engineering Symposium (IAFOE)
2010 Synthetic Biol. and Eng. Ethics Workshop, Woodrow Wilson Int. Center for Scholars
2010 NSF-supported Workshop on Synthetic Biology, Sustainability Science and Science & Technology Studies. Woodrow Wilson International Center for Scholars

REVIEW SERVICE

Science, Applied and Environmental Microbiology, Biochemistry, Biomacromolecules, Metabolic Engineering, Biotechnology and Bioengineering, Journal of Biotechnology, Microbial Cell Factories, Biochemical Engineering Journal, Bioresource Technology, Applied Microbiology and Biotechnology, Biotech Progress, Molecular Biosystems, Enzyme and Microbial Technology, Antonie van Leeuwenhoek, Journal of Microbiology, Lab on a Chip,

DOE Graduate Fellowship Program, NSF Catalysis and Biocatalysis, NSF BBBE, NSF Energy for Sustainability, Genome Canada, Air Force Office of Scientific Research, BBSRC

RELEVANT PUBLICATIONS (Total: 17 articles, 1 patent, 3 patent applications, 2 book chapters)

Underlined authors are undergraduates. Doubly underlined authors are high school students.

1. Mendez-Perez, D, Gunasekaran, S, Orler, VJ, **Pfleger BF**. A translation-coupling DNA cassette for monitoring protein translation in bacteria. *Metabolic Engineering*. (Accepted)
2. Youngquist JT, Lennen RM, Ranatunga DR, Bothfeld WH, Marner II WD, **Pfleger BF**. Kinetic modeling of free fatty acid production in *Escherichia coli* based on continuous cultivation of a plasmid free strain. 2012 *Biotechnol Bioeng*. Jun;109(6):1518-27 (2012).
3. Hoover SW, Youngquist JT, Angart PA, Withers ST, Lennen RM, **Pfleger BF**. Isolation of improved free fatty acid overproducing strains of *E. coli* via Nile red based high-throughput screening. *Environmental Progress & Sustainable Energy* Apr;**31**,(1):17–23 (2012).
4. Lennen RM, Kruziki MA, Kumar K, Zinkel RA, Burnum KE, Lipton MS, Hoover SW, Ranatunga DR, Wittkopp TM, Marner II WD, **Pfleger BF**. Membrane Stresses Induced by Endogenous Free Fatty Acid Overproduction in *Escherichia coli*. *Appl Environ Microb*. Nov;**77**(22):8114-28 (2011).
5. Mendez-Perez D, Begemann MB, **Pfleger BF**. A gene encoding a modular synthase is involved in α-olefin biosynthesis in *Synechococcus sp.* PCC7002. *Appl Environ Microb*. Jun;**77**(12):4264-7 (2011).
6. **Pfleger B F**. (2009) Future Applications of Metabolic Engineering. In *The Metabolic Engineering Handbook* (Smolke, CD. Editor, San Diego: CRC Press)

SYNERGISTIC ACTIVITIES

10 Invited Lectures at Universities and Research Centers
Univ. of Minnesota, 2/2/12; Penn State, 1/26/12; Cornell, 4/10/11; UIUC, 10/31/11
24 Invited Presentations at Conferences, Symposia, and Other Events
3M, 10/1611; ACS, 8/29/11; Biochemical Eng XVI, 7/6/09; Larry Meiller Show, 2/24/10
45 Presentations given at national meetings given by me and my students

JAMES B. RAWLINGS, Elfers Professor

PROFESSIONAL PREPARATION

1985-1986	Chemical Engineering NATO Postdoctoral Fellow, Institute for System Dynamics and Process Control University of Stuttgart, Stuttgart, Germany
1985	Ph.D. Chemical Engineering, University of Wisconsin–Madison
1979	B.S. Chemical Engineering, University of Texas at Austin

APPOINTMENTS

2000-2003	Chair, Department of Chemical and Biological Engineering University of Wisconsin–Madison
1995-present	Professor, Department of Chemical and Biological Engineering University of Wisconsin–Madison
1986–1995	Assistant and Associate Professor, Department of Chemical Engineering The University of Texas at Austin

SELECTED PUBLICATIONS

Rawlings, J. B. and D. Q. Mayne. *Model Predictive Control: Theory and Design*. Nob Hill Publishing, Madison, WI, 2009. 576 pages, ISBN 978-0-9759377-0-9.

Pannocchia, G., J. B. Rawlings, and S. J. Wright. Conditions under which suboptimal nonlinear MPC is inherently robust. *Sys. Cont. Let.*, 60:747–755, 2011.

Lima, F. V. and J. B. Rawlings. Nonlinear stochastic modeling to improve state estimation in process monitoring and control. *AIChE J.*, 57:996–1007, 2011.

Stewart, B. T., A. N. Venkat, J. B. Rawlings, S. J. Wright, and G. Pannocchia. Cooperative distributed model predictive control. *Sys. Cont. Let.*, 59:460–469, 2010.

Rajamani, M. R., J. B. Rawlings, and S. J. Qin. Achieving state estimation equivalence for misassigned disturbances in offset-free model predictive control. *AIChE J.*, 55(2):396–407, February 2009.

Rajamani, M. R. and J. B. Rawlings. Estimation of the disturbance structure from data using semidefinite programming and optimal weighting. *Automatica*, 45:142–148, 2009.

Odelson, B. J., A. Lutz, and J. B. Rawlings. The autocovariance least-squares methods for estimating covariances: Application to model-based control of chemical reactors. *IEEE Ctl. Sys. Tech.*, 14(3):532–541, May 2006.

Odelson, B. J., M. R. Rajamani, and J. B. Rawlings. A new autocovariance least-squares method for estimating noise covariances. *Automatica*, 42(2):303–308, February 2006.

Rao, C. V., J. B. Rawlings, and D. Q. Mayne. Constrained state estimation for nonlinear discrete-time systems: Stability and moving horizon approximations. *IEEE Trans. Auto. Cont.*, 48(2):246–258, February 2003.

SYNERGISTIC ACTIVITIES

RECENT CONFERENCES:

Invited speaker. IFAC Workshop on Hierarchical and Distributed Model Predictave Control, “An overview of distributed model predictive control,” Milan, Italy, September 2011.

Invited speaker, IFAC Workshop on Fifty Years of Nonlinear Control and Optimization, “Optimal Control Unchained: How Fast Online Computing Enabled Today’s Advanced Industrial Control Systems,” London, UK, September 2010.

Keynote speaker, International Workshop on Assessment and Future Directions of NMPC, "Optimizing process economic performance using model predictive control," Pavia, Italy, September 2008.

INDUSTRIAL CONSORTIUM AND INDUSTRIAL MPC SHORT COURSES:

The PI is co-director of the Texas Wisconsin California Control Consortium (TWCCC), which consists of more than 20 leading chemical, pharmaceutical, microelectronic and control companies. The PI has received research support from numerous companies. Current sponsors include Eastman Chemical, ExxonMobil, and Shell.

The PI has co-taught eight model predictive control (MPC) short courses to 100 industrial participants including on-site courses at Eastman Chemical and Exxon Chemical.

SOFTWARE DEVELOPMENT:

Since 2007 we have been distributing the complete source code and documentation for the autocovariance least squares (ALS) tools for use with Octave or MATLAB (jbrwww.che.wisc.edu/software/ als/). These tools provide a reference implementation of the algorithms developed by Rajamani, Odelson and Rawlings.

Since 1993 we have developed and distributed the freely-available numerical simulation language Octave.More than 10,500 copies of the sources for the latest stable version of Octave (3.0.3) have been downloaded from ftp.octave.org in the first two weeks since its release in October 2008. That number does not represent all copies distributed, however, as Octave is also available from ftp.gnu.org and its many mirrors, and most people download and install packaged binaries rather than installing from source. There are currently binary packages available for Debian, Fedora, and other Linux distributions, Mac OS X systems, and Windows.

COLLABORATORS & OTHER AFFILIATIONS

The PI has collaborated with the following researchers during the last 48 months: D. Angeli, R. Amrit, B. Bakshi, D. Bonne, E. Camacho, M. Diehl, K. Doshi, A. Ferramosca, N. Ferrier, R. Gudi, E.L. Haseltine, S. Hensel, I.A. Hiskens, J. Jorgensen, S. Jorgensen, V. Lam, P.A. Larsen, D. Limon, A. Lutz, W. Marquardt, E.A. Mastny, D.Q. Mayne, S. Middlebrooks, G. Pannocchia, D.B. Patience, S.J. Qin, M.R. Rajamani, T. Soderstrom, B. Stewart, J. Stoustrup, A. Venkat, Y. Wang, S.J. Wright, Z. Wu, J. Yin

The PI's Ph.D. advisor was Professor W. Harmon Ray, Department of Chemical Engineering, University of Wisconsin. The PI's postdoctoral sponsor was Professor E. D. Gilles, Institute for System Dynamics and Process Control, University of Stuttgart, Germany,

Ph.D. and M.S. graduates during the last five years (7): A.N. Venkat, E.L. Haseltine, S. Hensel, P.A. Larsen, E.A. Mastny, M.R. Rajamani. B. Stewart

Postdoctoral appointments and faculty visitors during the last five years (6): J.W. Eaton, A. Ferramosca, F. Lima, J.P. Maree, G. Pannocchia, E. Sokoler.

JENNIFER L. REED, Assistant Professor

EDUCATION

2005 Ph.D., Bioengineering, University of California, San Diego
Principal Advisor: Bernhard Palsson, Ph.D.
Thesis: Model Driven Analysis of Escherichia coli Metabolism

2002 Master of Science, Bioengineering, University of California, San Diego
Principal Advisor: Bernhard Palsson, Ph.D.

2000 Bachelor of Science, Bioengineering, University of California, San Diego
Summa Cum Laude

ACADEMIC EXPERIENCE

2007-present	Assistant Professor, Dept. of Chemical & Biological Engineering, University of Wisconsin-Madison
2007-present	Project Lead, Great Lakes Bioenergy Research Center
2005-2007	Faculty Fellow, Department of Bioengineering, University of California, San Diego
2000-2005	Graduate Student, Department of Bioengineering, University of California, San Diego
2003, 2006	Consultant, Genomatica
1999-2004	Teaching Assistant, University of California, San Diego
1999	Research Assistant, National Institutes of Health
1998-1999	Intern, General Atomics, San Diego

HONORS & ACTIVITIES

2011	NSF CAREER Awardee
2005-2007	University of California, Faculty Fellow
2001, 2003	Award for Excellence as a Teaching Assistant, Department of Bioengineering
2000-2001	Irwin and Joan Jacobs Fellow
1999-2000	Reuben H. Fleet Scholarship and William W. Stout Scholarship
1999	Participant in Whitaker Bioengineering Summer Internship Program at the NIH

PUBLICATIONS (Not all shown) * Indicates authors contributed equally towards the work

1. Kim J and JL Reed. Relative optimality in metabolic networks explains robust metabolic and regulatory responses to perturbations. Under Review (2012).
2. Hamilton JJ and JL Reed. Identification of Functional Differences in Metabolic Networks Using Comparative Genomics and Constraint-Based Models. PLoS ONE, 7(4):e34670 (2012).
3. Vu T*, Stolyar SS*, Pinchuk GE, Hill EA, Kucek LA, Brown RN, Lipton MS, Osterman AL, Fredrickson JK, Konopka AE, Beliaev AS, and JL Reed. Genome-Scale Modeling of Light-Driven Reductant Partitioning and Carbon Fluxes in Diazotrophic Unicellular Cyanobacterium Cyanothece sp. ATCC 51142Cyanothece sp. ATCC 51142. PLoS Computational Biology, 8(4):e1002460 (2012).

4. Schwalbach MS, Keating DH, Tremaine M, Marner WD, Zhang Y, Bothfeld W, Higbee A, Grass JA, Cotten C, Reed JL, da Costa Sousa L, Jin M, Balan V, Ellinger J, Dale B, Kiley PJ, and Landick R. Complex physiology and compound stress responses during fermentation of alkaline-pretreated corn stover hydrolysate by an Escherichia coli ethanologen. Applied and Environmental Microbiology, in press (2012).
5. Schellenberger J, Zielinski DC, Choi W, Madireddi S, Portnoy V, Scott DA, Reed JL, Osterman AL, and Palsson BO. Predicting outcomes of steady-state 13C isotope tracing experiments with Monte Carlo sampling. BMC Systems Biology, 1(1):9 (2012).
6. Baumler DJ, Peplinski RG, Reed JL, Glasner JD and NT Perna. The evolution of metabolic networks of E. coli. BMC Systems Biology, 5:182 (2011).
7. Pinchuk GE, Geydebrekdt OV, Hill EA, Reed JL, Konopka AE, Beliaev AS, and JK Fredrickson. Pyruvate and Lactate Metabolism by Shewanella oneidensis MR-1 under Fermentative, Oxygen-limited and Fumarate-Respiring Conditions. Applied and Environmental Microbiology, 77(23):8234-40 (2011).
8. Kim J, Reed JL, and CT Maravelias. Large-Scale Bi-Level Strain Design Approaches and Mixed-Integer Programming Solution Methods. PLoS ONE, 6(9):e24162 (2011).
9. Imam S, Yilmaz SL, Sohem U, Gorzalski AS, Reed JL, Noguera DR, and TJ Donohue. iRsp1095: A Genome-scale Reconstruction of the Rhodobacter sphaeroides metabolic network. BMC Systems Biology, 5:116 (2011).
10. Reed JL, Senger RS, Antoniewicz MR, and JD Young. Computational Approaches in Metabolic Engineering. Journal of Biomedicine and Biotechnology, 2010: 07414 (2010).
11. Chen X, Alonso AP, Allen DK, Reed JL, and Y Shachar-Hill. Synergy between 13C-metabolic flux analysis and flux balance analysis for understanding metabolic adaption to anaerobiosis in E. coli. Metabolic Engineering, 13(1):38-48 (2011).
12. Thiele I, Hyduke DR, Steeb B, Fankam G, Allen DK, Bazzani S, Charusanti P, Chen FC, Fleming RM, Hsiung CA, De Keersmaecker SC, Liao YC, Marchal K, Mo ML, Ozdemir E, Raghunathan A, Reed JL, Shin SI, Sigurbjornsdottir S, Steinmann J, Sudarsan S, Swainston N, Thijs IM, Zengler K, Palsson BO, Adkins JN, Bumann D. A community effort towards a knowledge-base and mathematical model of the human pathogen Salmonella Typhimurium LT2. BMC Systems Biology, 5(1):8 (2011).
13. Barua D*, Kim J*, and JL Reed. An automated phenotype-driven approach (GeneForce) for refining metabolic and regulatory models. PLoS Computational Biology, 6(10):e1000970 (2010).
14. Kim J, and JL Reed. OptORF: Optimal metabolic and regulatory perturbations for metabolic engineering of microbial strains. BMC Systems Biology, 4:53 (2010).
15. Pinchuk G*, Hill EA, Geydebrekht OV, De Ingeniis J, Zhang X, Osterman A, Scott JH, Reed SB, Romine MF, Konopka AE, Beliaev AS, Fredrickson JK, and JL Reed*. Constraint-based model of Shewanella oneidensis MR-1 metabolism: a tool for data analysis and hypothesis generation. PLoS Computational Biology, 6(6):e1000822 (2010).
16. Wier A, Nyholm S, Mandel M, Massengo-Tiassé R, Schaefer A, Koroleva I, Splinter BonDurant S, Brown B, Manzella L, Snir E, Almabrazi H, Scheetz T, de Fatima Bonaldo M, Casavant T, Soares M, Cronan J, Reed J, Ruby E, and M McFall-Ngai.. Transcriptional patterns in both host and bacterium underlie a daily rhythm of ultrastructural and metabolic change in a beneficial symbiosis. Proc Natl Acad Sci U S A, 107(5):2259-64 (2010).

THATCHER W. ROOT, Professor

PROFESSIONAL PREPARATION

1984-86 Postdoctoral Member of Technical Staff, AT&T Bell Laboratories, Murray Hill, NJ
Organic Materials and Chemical Engineering Department
Research Topic: NMR studies of heterogeneous catalysis

1979-84 University of Minnesota, Minneapolis, MN, Ph.D. in Chemical Engineering

1975-79 Massachusetts Institute of Technology, Cambridge, MA
S.B. in Chemistry, S.B. in Chemical Engineering

APPOINTMENTS

2011-present Professor of Chemical Engineering, University of Wisconsin-Madison

1992-2011 Associate Professor of Chemical Engineering, University of Wisconsin-Madison

1986-92 Assistant Professor of Chemical Engineering, University of Wisconsin-Madison

PROFESSIONAL AFFILIATIONS AND ACTIVITIES

ACS, AIChE

HONORS AND AWARDS

UW Teaching Academy
Polygon Outstanding Instructor Award 2000, 2002, 2003, 2008, 2009
Benjamin Smith Reynolds Award for Excellence in Teaching Engineers 2010
NSF Presidential Young Investigator Award 1987-92

RECENT PATENTS AND PATENT APPLICATIONS (5 total)

1. METHOD FOR RECOVERY OF LEVULINIC ACID FROM AQUEOUS SOLUTIONS OF MINERAL ACIDS, J. Dumesic, D. Martin Alonso, J. Bond, T. Root, WARF P110124US, disclosure filed 1/3/11.
2. AN EXAMPLE OF PROCESS INTENSIFICATION: PROCESS SCALE CHROMATOGRAPHY, E. Lightfoot, N. Abbott, T. Root, WARF disclosure filed 9/20/10.
3. DAIRY PROTEIN FRACTIONATION USING CHARGED ULTRAFILTRATION MEMBRANES, M. Etzel, T. Root, S. Gemli, A. Arunkumar, disclosure filed 7/15/10.
4. EXTENDED-RANGE HEAT TRANSFER FLUID USING VARIABLE COMPOSITION, T. Root, WARF P08455US02; disclosure filed 8/13/08, provisional patent application 9/4/09, s/n 61/239,883, patent application filed 9/3/10, s/n 12/875,420.

SELECTED PUBLICATIONS (Total refereed papers: 65)

1. "Production of γ-valerolactone from cellulose and corn stover using alkylphenol solvents," D. M. Alonso, S. G. Wettstein, J. Q. Bond, T. W. Root, and J. A. Dumesic, *ChemSusChem* **4** (2011) 1078-1091.
2. "Challenges of supported phosphate and carbonate salts as catalysts for biodiesel synthesis," S. L. Britton, J. Q. Bond, and T. W. Root, *Energy Fuels,* 24(7) (2010) 4095-4096.
3. "Photo-catalytic oxidation of low molecular weight alkanes over supported ZrO_2-TiO_2 thin films in a plug-flow tubular reactor," T. M. Twesme, D. T. Tompkins, M. A. Anderson, T. W. Root, *Applied Catalysis B: Environmental* **64** (2006) 153-160.

4. “The Effect of Carbon Monoxide on the Oxidative Carbonylation of Methanol to Dimethyl Carbonate over Cu^+X and Cu^+ZSM-5 Zeolite Catalysts,” S. A. Anderson and T. W. Root, *Journal of Molecular Catalysis A: Chemical* **220** (2004) 247-255.
5. “The Effect of High Intensity Mixing on the Enzymatic Hydrolysis of Concentrated Cellulose Fiber Suspensions,” J. R. Samaniuk, C. T. Scott, T. W. Root, and D. J. Klingenberg, *Bioresource Technology* **102** (2011) 4489-4494.
6. “Rheology of dilute acid hydrolyzed corn stover at high solids concentration,” M. R. Ehrhardt, T. O. Monz, T. W. Root, R. K. Connelly, C. T. Scott, D. J. Klingenberg, *Appl. Biochem. Biotech*., **160** (2009) 1102-1115.
7. “Emergence of ideal membrane cascades for downstream processing,” E. N. Lightfoot, T. W. Root, and J. L. O’Dell, *Biotechnology Progress* **24** (2008) 599-605.
8. “Detailed diesel exhaust particulate characterization and real-time DPF filtration efficiency measurements during PM filling process,” E. Wirojsakunchai, E. Schroeder, C. Kolodziej, D. Foster, N. Schmidt, T. Root, T. Kawai, T. Suga, T. Nevius, and T. Kusaka, SAE 2007 World Congress, 07PFL-420.

SYNERGISTIC ACTIVITIES

Sustainability Advocacy

Certificate program: Engineering for Energy Sustainability - Steering Committee
CBE 562/511: Energy Technologies and Sustainability – senior/graduate elective course on current energy sources, conservation, and renewable energy (taught 4 years)
Guest lecturer on “Sustainability” for InterEgr 160 - Freshman Engineering Design Introduction course each fall and spring semester for 3 years

Delta Program in Research Teaching and Learning (NSF CIRTL prototype community)

EPD 654 – College Classroom: taught pedagogy course for faculty-bound graduate students
Presenter in Engineering TA training sessions
DELTA Steering Committee

Undergraduate Research Supervisor

Hosted summer visitors for REU experiences in lab
Provided lab projects for Chem 116 Honors Chemistry freshmen
Senior research projects – typically 2-4 Chemical Engineering students in lab

RESEARCH COLLABORATORS

Graduate Students, last 4 years (32 graduate students advised, total)

Stephanie Britton	PhD ‘07
Max Ehrhardt (with D. J. Klingenberg)	MS ‘08
Jesse Bond	PhD ‘09
Joe Samuniak (with D. J. Klingenberg)	PhD student
David Mannell (with S. Stahl, Chemistry)	PhD student
Jodie Greene (with S. Stahl, Chemistry)	PhD student

Research Mentors

Thesis advisor: Lanny Schmidt	University of Minnesota
Postdoc: T. Michael Duncan	AT&T Bell Laboratories, now Cornell University

ERIC V. SHUSTA, Associate Professor

PROFESSIONAL PREPARATION

1999-2001	Neuroscience, University of California-Los Angeles
1999	Ph.D. Chemical Engineering, University of Illinois-Urbana
1998	M.S. Chemical Engineering, University of Illinois-Urbana
1994	B.S. Chemical Engineering, University of Wisconsin-Madison

APPOINTMENTS

2007-present	Associate Professor, Dept. of Chemical and Biological Engineering, University of Wisconsin
2002-present	Affiliated Faculty, Dept. of Biomedical Engineering, University of Wisconsin
2001-2007	Assistant Professor, Dept. of Chemical and Biological Engineering, University of Wisconsin
1999-2001	Postdoctoral Fellow, Dept. of Medicine, University of California-Los Angeles. Advisor: Dr. William M. Pardridge. Analysis of blood-brain barrier genomics and proteomics
1994-1999	Research Associate, Dept. of Chemical Engineering, University of Illinois. Advisor: Dr. K. Dane Wittrup. Thesis: The Production of Recombinant Immunoglobulin Superfamily Proteins in the Yeast *Saccharomyces cerevisiae*

SELECTED PUBLICATIONS

Lippmann E.S., Azarin S.M., Kay J.E., Nessler R.A., Wilson H.K., Palecek S.P., **Shusta E.V**., Human Blood-Brain Barrier Endothelial Cells Derived from Pluripotent Stem Cells, *Nature Biotechnology*, in press, 2012.

Cho Y.K., **Shusta E.V**., Antibody Library Screens Using Detergent-Solubilized Mammalian Cell Lysates as Antigen Sources, *Protein Engineering Design Selection*, **23**, 567-577, 2010.

Pavoor T.V., Cho Y.K., **Shusta E.V**., Development of GFP-based Biosensors Possessing the Binding Properties of Antibodies, *Proceedings of the National Academy of Sciences, USA*, 106, 11895-11900, 2009.

Wentz A.E. and **Shusta E.V.**, A Novel High Throughput Screen Reveals Yeast Genes that Increase Heterologous Protein Secretion, *Applied and Environmental Microbiology*, **73**, 1189-1198, 2007.

Huang D., **Shusta E.V.**, A Yeast Platform for the Production of Single-Chain Antibody-Green Fluorescent Protein Fusions, *Applied and Environmental Microbiology*, **72**, 7748-7759, 2006.

Agarwal N., **Shusta E.V.**, Multiplex Expression Cloning of Blood-brain Barrier Membrane Proteins, *Proteomics*, **9**, 1099-1108, 2009.

Calabria A.R., **Shusta E.V.**, A Genomic Comparison of *In Vivo* and *In Vitro* Brain Microvascular Endothelial Cells, *Journal of Cerebral Blood Flow and Metabolism*, 28, 135-148, 2008.

SYNERGISTIC ACTIVITIES

<u>Innovations in teaching:</u> I have updated the undergraduate Mass Transfer Operations course that I regularly teach to include many problem solving examples with origins in the biological

sciences. I developed a course in molecular and cellular engineering suitable for graduate students called “Design of Biological Molecules”.

Contributions to learning: Protein engineering concepts developed in the graduate course above were adapted to form a protein engineering symposium for the Wisconsin Science Olympiad for 15 high school students from around the state that detailed protein structure, protein engineering, and engineering design.

Participation in training underrepresented students: I have hosted two REU students from underrepresented groups and both are now attending graduate school at the University of Wisconsin. In addition, I have trained three underrepresented graduate students, two of whom have moved on to industrial and post-doctoral positions, and one who is finishing her PhD. Each year, I also meet with 5-10 diversity students in the Opportunities in Engineering Conference held at Wisconsin introducing them to the chemical and biological engineering department and walking them through the process of applying to graduate school.

Service outside the University: I have acted as chair of many sessions at international scientific meetings including ACS, AIChE, and Keystone meetings. I have participated in peer review for NSF, NIH, US department of veterans affairs, and other private foundations. I actively participate in the peer review process for a wide range of journals such as Nature Biotechnology, Biotechnology and Bioengineering, Blood, Proteomics, and Stroke.

COLLABORATORS AND OTHER AFFILIATIONS

E.T. Boder, University of Tennessee
K. Lee, University of Delaware
C.N. Svendsen, University of Wisconsin
H.E. de Vries, Vrije Universiteit, Amsterdam
John S. Kuo, University of Wisconsin
N.L. Abbott, University of Wisconsin
P. Bertics, University of Wisconsin

GRADUATE AND POSTDOCTORAL ADVISORS

K.D. Wittrup, MIT
R.J. Boado, UCLA
W.M. Pardridge, UCLA

THESIS ADVISEES (Not all shown) (Total 13)

Anthony Calabria – Genencor
Xin Xiang Wang – Postdoc
Alane Wentz – Abbott Laboratories
Dagang Huang - Abbott Laboratories
Mike Burns – Medical Student, Northwestern

POSTDOCS (2)

Christian Weidenfeller, Merck Serono
Xiaobin Zhang – current post-doc

ROSS E. SWANEY, Associate Professor

EDUCATION

1983	Ph.D.	Carnegie-Mellon University (Chemical Engineering).
1980	MBA	University of Chicago Graduate School of Business.
1978	MSChE	Carnegie-Mellon University.
1976	BSChE	Carnegie-Mellon University (University Honors).

EMPLOYMENT

University of Wisconsin, Chemical Engineering (27 years on faculty)

7-91 to present	Associate Professor
1996-97	Vilas Associate
1994	Visiting Professor, Lehrstuhl fuer Prozesstechnik RWTH-Aachen, Germany
(1-85 to 6-91)	Assistant Professor

Industrial Experience

(1984; 1977-80) Senior Engineer, Process Design, ARCO Petroleum Products Company.

SOCIETY MEMBERSHIPS

American Institute of Chemical Engineers
Computing and Systems Technology Division, AIChE

AWARDS AND HONORS

U.S.D.A. Group Honor Award for Environmental Protection (1997)
Federal Laboratory Consortium Award for Excellence in Technology Transfer (Biopulping), 1998
Forest Service Chief's Award for Excellence in Technology Transfer, 1998

INSTITUTIONAL AND PROFESSIONAL SERVICE

University

UW Conflict of Interest Committee
UW Nuclear Reactor Safety Committee
UW Biotechnology Center biopulping project
USDA Forest Products Laboratory: Consultant on multiple collaborative projects.

College

Byron Bird Award Committee

Department

Graduate Credentials Committee
Curriculum Committee
Undergraduate advisor
New graduate student advisor
Summer Lab participation and development

CONSULTING AND PATENTS

Paper industry collaborations for development/transfer of oxalic acid and biopulping technologies: Alabama River, Augusta Newsprint, Bowater, Packaging Corporation of America, PISA, Ponderay, Melhoramentos Papéis, Mondi Papers S.A., Stora-Enso North America, Weyerhauser,. Pilot plant design and fabrication: Affliated Engineers, Inc. Full-scale design studies: Harris Group.

Argonne National Laboratory: Process design and modeling collaboration for spent nuclear fuel processing.; Program reviewer.

Nalco, Inc.: Architectures and convergence methods for flowsheet modeling software.

Akhtar, M., E.G. Horn, R.E. Swaney, C. Zhiyong, "Method for Producing Pulp by Application of Oxalic Acid", provisional application filed May 25, 2012.

Akhtar, M., W.R. Kenealy, E.G. Horn, R.E. Swaney, and J. Winandy, "Method of Making Medium Density Fiberboard", U.S. Patent 8,123,904 issued February 28, 2012.

Kenealy, W.R., E.G. Horn, M. Akhtar, and R.E. Swaney, "Method for Treating Lignocellulosic Materials"'. US Patent 8,092,647 B2 issued January 10, 2010.

Akhtar, M., R.E. Swaney, E.G. Horn, M.J. Lentz, G.M. Scott, C.C. Black, C.J. Houtman, and T.K. Kirk, "Method for Producing Pulp"'. U.S. Patent 7,306,698 issued December 11, 2007.

SELECTED PUBLICATIONS

Wardle, K.E., T.R. Allen, M.H. Anderson, and R.E. Swaney, "Experimental Study of the Hydraulic Operation of an Annular Centrifugal Contactor with Various Mixing Vane Geometries", AIChE J., 56, 8, 1960-1974 (2010).

Wardle, K. E., T. R. Allen, M. H. Anderson, R. Swaney. "Analysis of the Effect of Mixing Vane Geometry on the Flow in an Annular Centrifugal Contactor", AIChE J., 55, 2244-2259 (2009).

Wardle, K.E., T.R. Allen, and R. Swaney, "CFD Simulation of the Separation Zone of an Annular Centrifugal Contactor", Separ. Sci. Technol., 44, 10, 517-542 (2009).

Wardle, K.E., T.R. Allen, M.H. Anderson, R.E. Swaney, "Free Surface Flow in the Mixing Zone of an Annular Centrifugal Contactor", AIChE J., 54, 74-85 (2008).

Kenealy, W., E. Horn, M. Davis, R. Swaney, and C. Houtman, "Vapor Phase Diethyl Oxalate Pretreatment of Wood Chips: Part 2, Release of Hemicellulosic Carbohydrates"', Holzforschung, 61, 3, 230-235 (2007).

Wardle, K.E., T.R. Allen, and R. Swaney, "Computational Fluid Dynamics (CFD) Study of the Flow in an Annular Centrifugal Contactor"', Separ. Sci. Technol., 41, 10, 2225-2244 (2006).

Cisternas, L.A., C.M. Vasquez, and R.E. Swaney, "On the design of crystallization-based separation processes: Review and extension", AIChE J. (2006).

Guirardello, R. and R.E. Swaney, "Optimization of process plant layout with pipe routing", Comp. & Chem. Eng., 30, 99-114 (2005).

Galvez, E.D, C.A. Vega, R.E. Swaney, and L.A. Cisternas, "Design of Solvent Extraction Circuit Schemes", Hydrometallurgy, 74, 19-38 (2004).

Cisternas, L., J. Cueto, and R. Swaney, "Flowsheet Synthesis of Fractional Crystallization Processes with Cake Washing", Computers & Chem. Eng., 28, 613-623 (2004).

Cisternas, L.A., M.A. Torres, M.J. Godoy, and R.E. Swaney, "Design of Separation Schemes for Fractional Crystallization of Metathetical Salts", AIChE Journal, 49, 7, 1731-1742 (2003).

JOHN YIN, Professor

EDUCATION
1988-1992, Post-doc, Biophysical Chemistry, Max-Planck-Institute (Germany)
1988, Ph.D., Chemical Engineering, University of California-Berkeley
1983, BS, Chemical Engineering, Columbia University
1982, BA (magna cum laude), Liberal Arts, Columbia University

ACADEMIC EXPERIENCE
University of Wisconsin-Madison,
Systems Biology, Theme Leader, Wisconsin Institute for Discovery (2009-date)
Department of Chemical and Biological Engineering:
Professor (2004-date)
Associate Professor (1998-2004)
Dartmouth College, Thayer School of Engineering, Assistant Professor (1992-1998)

CURRENT MEMBERSHIPS
American Institute of Chemical Engineers (AIChE)
American Society for Virology (ASV)

HONORS AND AWARDS
2009 – present Wisconsin Institute for Discovery (WID) Award, UW-Madison
- new lab/office space and resources to hire 3 new tenure-track faculty in systems biology
1998 – 2000 Cargill Faculty Fellowship, University of Wisconsin-Madison
1997 – 1999 U.S. National Science Foundation Presidential Early Career Award for Science and Engineering (PECASE)
1994 – 1997 U.S. National Science Foundation Young Investigator Award
1990 – 1992 Research Fellowship, Max Planck Society, Germany
1988 – 1990 Alexander von Humboldt Foundation, Post-doctoral Fellowship, Germany

SERVICE ACTIVITIES
Member, National Institutes of Health (NIH), *Modeling and Analysis of Biological Systems (MABS) Study Section*, 2010 – 2014

RECENT PUBLICATIONS AND PRESENTATIONS
[1] Haseltine, E. L., Lam, V., Yin, J., and Rawlings, J. B. (2008). Image-guided modeling of virus growth and spread. Bulletin of Mathematical Biology *70*, 1730-1748.
[2] Haseltine, E. L., Yin, J., and Rawlings, J. B. (2008). Implications of Decoupling the Intracellular and Extracellular Levels in Multi-Level Models of Virus Growth. Biotechnology and Bioengineering *101*, 811-820.
[3] Abedon, S. T., and Yin, J. (2009). Bacteriophage plaques: theory and analysis. Methods Mol Biol *501*, 161-174.
[4] Anekal, S. G., Zhu, Y., Graham, M. D., and Yin, J. (2009). Dynamics of virus spread in the presence of fluid flow. Integr Biol (Camb) *1*, 664-671.
[5] Hensel, S. C., Rawlings, J. B., and Yin, J. (2009). Stochastic kinetic modeling of vesicular stomatitis virus intracellular growth. Bull Math Biol *71*, 1671-1692.

[6] Hensel, S. C., Rawlings, J. B., and Yin, J. (2009). Stochastic Kinetic Modeling of Vesicular Stomatitis Virus Intracellular Growth. Bulletin of Mathematical Biology *71*, 1671-1692.
[7] Lim, K. I., and Yin, J. (2009). Computational fitness landscape for all gene-order permutations of an RNA virus. PLoS Comput Biol *5*, e1000283.
[8] Stauffer Thompson, K. A., Rempala, G. A., and Yin, J. (2009). Multiple-hit inhibition of infection by defective interfering particles. J Gen Virol *90*, 888-899.
[9] Zhu, Y., Warrick, J. W., Haubert, K., Beebe, D. J., and Yin, J. (2009). Infection on a chip: a microscale platform for simple and sensitive cell-based virus assays. Biomed Microdevices *11*, 565-570.
[10] Zhu, Y., Yongky, A., and Yin, J. (2009). Growth of an RNA virus in single cells reveals a broad fitness distribution. Virology *385*, 39-46.
[11] Thompson, K. A., and Yin, J. (2010). Population dynamics of an RNA virus and its defective interfering particles in passage cultures. Virol J *7*, 257.
[12] Lindsay, S. M., Timm, A., and Yin, J. (2012). A quantitative comet infection assay for influenza virus. J Virol Methods *179*, 351-358.
[13] Timm, A., and Yin, J. (2012). Kinetics of virus production from single cells. Virology *424*, 11-17.

Selected **Invited Presentations** in last five years: Harvard Med. School, Stanford, UC-San Diego, Penn; U. Minnesota-Minneapolis, U Wash, Texas A&M, Colorado State, Research Triangle Park, North Carolina.

PROFESSIONAL DEVELOPMENT

1. Co-organizer, Hot Topics Workshop, Stochastic Models for Intracellular Reaction Networks, Institute for Mathematics and its Applications (IMA), May 11-13, 2008, University of Minnesota-Minneapolis.
2. Invited panelist, National Institutes of Health (NIH), Special Reviews in Bioengineering, 8 August 2008, teleconference.
3. Invited participant, Conference on Dynamics of Host-Associated Microbial Communities, National Institute of General Medical Sciences, NIH, 13-14 November 2009.
4. Invited panelist, National Institutes of Health (NIH), Special Reviews in Bioengineering, 30 January 2009, teleconference.
5. Invited panelist, "Anticipating the Species Jump: Bioinformatics and Information Sharing," March 2011. Defense Threat Reduction Agency (DTRA), McLean, Virginia.

Appendix B – Course Syllabi

Chemical and Biological Engineering courses:

CBE 250 – Process Synthesis
CBE 255 – Introduction to Chemical Process Modeling
CBE 310 – Chemical Process Thermodynamics
CBE 311 – Thermodynamics of Mixtures
CBE 320 – Introductory Transport Phenomena
CBE 324 – Transport Phenomena Lab
CBE 326 – Momentum and Heat Transfer Operations
CBE 424 – Operations and Process Laboratory
CBE 426 – Mass Transfer Operations
CBE 430 – Chemical Kinetics and Reactor Design
CBE 440 – Chemical Engineering Materials
CBE 450 – Process Design
CBE 470 – Process Dynamics and Control
CBE 540 – Polymer Science and Technology
CBE 544 – Processing of Electronic Materials
CBE 547 – Introduction to Colloid and Interface Science

Curriculum courses from other departments:

Biochem 501 – Introduction to Biochemistry

Chem 109 – Advanced General Chemistry
Chem 329 – Fundamentals of Analytical Science
Chem 343 – Introductory Organic Chemistry
Chem 344 – Introductory Organic Chemistry Lab
Chem 345 – Intermediate Organic Chemistry
Chem 562 – Physical Chemistry

Genetics 466 – General Genetics

Math 221 – Calculus and Analytical Geometry 1
Math 222 – Calculus and Analytical Geometry 2
Math 234 – Calculus—Functions of Several Variables
Math 319 – Techniques in Ordinary Differential Equations
Math 320 – Linear Algebra and Differential Equations

Microbiology 303 – Biology of Microorganisms

Physics 201 – General Physics
Physics 202 – General Physics

Statistics 324 – Introductory Applied Statistics for Engineers

Zool 153 – Introductory Biology
Zool 570 – Cell Biology

CBE 250 - Process Synthesis

Credits: 3 **Contact Hours:** 4.4

Course Coordinator: ROOT, THATCHER W

Textbook: R. M. Murphy, Introduction to Chemical Processes: Principles, Analysis, Synthesis, McGraw-Hill, 2005.

Supplemental Material:
In-class handouts and readings.

Catalog Description:
An introduction to the invention of processes for the large scale, low cost processing of materials such as water, chemicals, petroleum products, food, drugs and wastes. Open to students in any field.

Prerequisite(s): Chem 329 or cons inst

This Course is: Required

Specific ABET Outcomes:

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

Specific Course Outcomes:

a) Familiarity with chemical process flowsheeting and common unit operations
b) Ability to apply Mass and Energy Balances to chemical processes and unit operations
c) Understanding of factors involved in a successful chemical process, and ability to suggest possible new processes

Brief List of Topics:

a) Units, dimensions

b) Flow charts
c) Material balances
d) Recycle, bypass, purge
e) Material balances on reacting systems
f) Combustion processes
g) Elementary phase equilibrium
h) Staged separations – extraction
i) Energy balances - non-reactive and reactive systems
j) Enthalpy contributions - sensible heats, latent heats, heats of reaction
k) Combined mass and energy balances
l) Basic heat exchanger design and application strategies
m) Basic process synthesis (class project)

CBE 255 - Introduction to Chemical Process Modeling

Credits: 3 **Contact Hours:** 3.2

Course Coordinator: SWANEY, ROSS E

Textbook: R. Pratap, Getting Started with MATLAB, Oxford University Press, 2009

Supplemental Material: None

Catalog Description:
Introduction to modeling of chemical processes and introduction to using modern computational tools to analyze the models.

Prerequisite(s): Math 319 or 320 or cons inst

This Course is: Required

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
e) an ability to identify, formulate, and solve engineering problems
i) a recognition of the need for, and an ability to engage in life-long learning
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

When class project uses groups, include
d) an ability to function on multi-disciplinary teams

Specific Course Outcomes:

a) Develop facility with using modern computational software for numerical problem solving
b) Obtain an integrative overview of the entire chemical engineering curriculum
c) Be exposed to key modeling concepts for courses later in the curriculum
d) Acquire a set of tools that will be useful in later CBE courses
e) Be exposed to problems in stoichiometry of chemical reactions, diffusion and heat transfer, process systems steady-state modeling and design, chemical kinetics in well-mixed reactors, staged separations, estimating parameters from data

Brief List of Topics:

a) Programming in MATLAB
b) Computational/Numerical Methods (integration methods, solving systems of algebraic equations, parameter estimation)
c) Stoichiometry of Chemical Reactions
d) Process Systems Modeling and Designs

e) Chemical Kinetics in Reactors
f) Parameter Estimation
g) Diffusion and Heat Transfer

CBE 310 - Chemical Process Thermodynamics

Credits: 3   **Contact Hours:** 3.3

Course Coordinator: PFLEGER, BRIAN F.

Textbook: Elliott, J. R., and Lira, C. T., Introductory Chemical Engineering Thermodynamics, 2nd ed., 2012

Supplemental Material:
"Thermo" 2000 by Jay Schieber and Juan de Pablo

Catalog Description:
Introduction to thermodynamics, energy balances, applications to steady state and unsteady state processes, behavior of pure fluids, chemical reaction equilibria.

Prerequisite(s): Math 234, Physics 201 or equiv; CBE 255 or equiv or con reg; CBE 250 with a grade of C or better

This Course is: Required

Specific ABET Outcomes:
- a) an ability to apply knowledge of mathematics, science, and engineering
- e) an ability to identify, formulate, and solve engineering problems
- f) an understanding of professional and ethical responsibility
- g) an ability to communicate effectively
- h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:
- a) The student will learn the relationship between heat and work by understanding the significance of the first law of thermodynamics.
- b) The student will understand the limitations imposed by the second law of thermodynamics on the conversion of heat to work.
- c) The student will learn the definitions and relationships among the thermodynamic properties of pure materials, such as internal energy, enthalpy, and entropy.
- d) The student will learn how to obtain or to estimate the thermal and volumetric properties of real fluids.
- e) The student will understand the applications of energy balances in the analysis of batch, flow, and cyclical processes, including power cycles, refrigeration, and chemical reactors.

Brief List of Topics:

a) First law of thermodynamics.
b) Volumetric properties and equations of state of pure fluids.
c) Sensible and latent heat effects and heats of reaction
d) Second law of thermodynamics.
e) Definition of entropy and the third law.
f) Maxwell relations and other relations among properties.
g) Correlations of the thermal and volumetric properties of real fluids.
h) Flow processes.
i) Power cycles.
j) Turbines and jet engines.
k) Refrigeration cycles, heat pumps, and liquefaction of gases.

CBE 311 - Thermodynamics of Mixtures

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: MURPHY, REGINA M.

Textbook: Elliott and Lira, Introductory Chemical Engineering Thermodynamics, Prentice-Hall, 1st ed, 1999.

Supplemental Material:
"Thermo 2000" by Jay Schieber and Juan de Pablo

Catalog Description:
Properties of ideal and non-ideal vapors and liquids, ideal and non-ideal multicomponent vapor-liquid and liquid-liquid equilibria, complex chemical reaction equilibria, electrolytic solutions, surface thermodynamics, solid phase thermodynamics.

Prerequisite(s): CBE 211 with grade of C or better

This Course is: Required

Specific ABET Outcomes:
a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:
a) Ability to apply chemical thermodynamics to systems to determine phase and chemical equilibrium
b) Familiarity with terminology, theory, and common models used to describe solutions and mixtures

Brief List of Topics:
a) Solution thermodynamics
b) Ideal and Real mixtures
c) Vapor-liquid equilibrium
d) Liquid-liquid equilibrium
e) Vapor-liquid-liquid equilibrium
f) Solid-liquid equilibrium

g) Equations of state
h) Chemical reaction equilibrium

CBE 320 - Introductory Transport Phenomena

Credits: 4 **Contact Hours:** 4.4

Course Coordinator: KLINGENBERG, DANIEL J

Textbook: Bird, Stewart and Lightfoot, Transport Phenomena, 2nd ed. rev., Wiley, 2007.

Supplemental Material: None

Catalog Description:
Mass, momentum, and energy transport; calculation of transport coefficients; solution to problems in viscous flow, heat conduction, and diffusion; dimensional analysis; mass, momentum, and heat transfer coefficients; over-all balances; elementary applications.

Prerequisite(s): Physics 201, Math 319 or 320, CBE 250 with grade of C or better; or cons inst

This Course is: Required

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:

a) Set up shell balances for conservation of momentum, energy, and mass
b) Understand and apply flux laws in balances
c) Understand and apply interphase transport relationships
d) Employ shell balance equations to obtain desired profiles for velocity, temperature and concentration
e) Reduce and solve the appropriate equations of change to obtain desired profiles for velocity, temperature and concentration
f) Reduce and solve appropriate macroscopic balances for conservation of momentum, energy and mass
g) Utilize information obtained from solutions of the balance equations to obtain engineering quantities of interest
h) Recognize and apply analogies among momentum, heat and mass transfer
i) Appreciate relevance of transport principles in diverse applications of chemical, biological, and materials science and engineering

Brief List of Topics:

a) Mass, momentum and energy transport mechanisms
b) Calculation of transport coefficients
c) Dimensional analysis
d) Momentum, energy and mass interphase transport
e) Microscopic and macroscopic balances
f) Solution to problems in viscous flow, energy and mass transport
g) Elementary applications

CBE 324 - Transport Phenomena Lab

Credits: 3 **Contact Hours:** 4.1

Course Coordinator: CODNER, ERIC P

Textbook: CBE 324 Lab Notes, available online or at Bob's Copy Shop each semester

Supplemental Material: None

Catalog Description:
Determination of thermodynamic properties, transport properties, and transfer coefficients; study of related phenomena.

Prerequisite(s): CBE 310 & 320, or con reg; Stat 324

This Course is: Required

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Specific Course Outcomes:

a) Introduces engineering lab practice
b) Develops engineering report preparation and writing skills
c) Demonstrates the basic concepts of transport phenomena
d) Illustrates the application of the macroscopic balances of mass, energy, and chemical species

Brief List of Topics:

a) Pressure-volume-temperature behavior of gases
b) Viscosities of Newtonian liquids
c) Velocity profiles for turbulent flow
d) Friction factors for flow in circular tubes
e) Efflux time for a tank with an exit pipe
f) Thermal conductivity of solids
g) Temperature profiles on solids

h) Heat-transfer coefficients in circular tubes
i) Heating liquids in tank storage
j) Diffusivity in gases
k) Concentration profiles in a stagnant film

CBE 326 - Momentum and Heat Transfer Operations

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: CHAVEZ-CONTRERAS, RAFAEL

Textbook: McCabe, Smith, and Harriott, Unit Operations of Chemical Engineering, 7th ed., McGraw-Hill, 2007.

Supplemental Material:

Bird, Stewart, and Lightfoot, Transport Phenomena, Wiley, 1960.
Holman, Heat Transfer, 5th Edition, McGraw-Hill, 1981
Coulson, Richardson, Sinnott, Chemical Engineering, Vol 6, 2nd Edition, Pergamon Press, 1993
van Dyke, An Album of Fluid Motion, Parabolic Press, 1982

Catalog Description:

Analysis of chemical engineering operations involving fluid flow and heat transfer. Flow of fluids through ducts and porous media; motion of particulate matter in fluids; general design and operation of fluid-flow equipment.
Conductive, convective and radiative heat exchange with and without phase change; general design and operation of heat-exchange equipment.

Prerequisite(s): CBE 310 & 320 with grades of C or better

This Course is: Required

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:

a) Ability to apply thermodynamics and transport phenomena to analyze and design chemical process equipment
b) Familiarity with the theory and design equations describing common chemical engineering process equipment

Brief List of Topics:

a) Dimensional Analysis and Scale-Up
b) Mechanical Energy Balances
c) Flow of Incompressible Newtonian and Non-Newtonian Fluids
d) Flow of Compressible Fluids
e) Flow Measurement
f) Pumps, Compressors, Fans and Blowers
g) Two Phase Flow
h) Drag Coefficients and Settling
i) Packed Beds, Fluidized Beds, and Filtration
j) Cyclones and Centrifuges
k) Agitation and Mixing
l) Conduction in Solids
m) Heat Transfer Coefficients
n) Forced and Free Convection
o) Boiling and Condensation
p) Heat Exchangers
q) Evaporators
r) Radiation

CBE 424 - Operations and Process Laboratory

Credits: 5 **Contact Hours:** 200

Course Coordinator: ROOT, THATCHER W

Textbook: Lab Manual, from Bob's Copy Shop

Supplemental Material: None

Catalog Description:
Experiments in unit operations, and supervised individual assignments selected from areas such as: fluid dynamics, analytical methods, reaction kinetics, plastics technology, and use of computers in data processing and simulation.

Prerequisite(s): ChE 311, 324, 326 & 426, or cons inst

This Course is: Required

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
c) an ability to design a system, component, or process to meet desired needs
d) an ability to function on multi-disciplinary teams
g) an ability to communicate effectively
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
l) ability to solve a wide variety of problems in subject areas within which chemical engineers frequently practice, also including associated process hazards.

Specific Course Outcomes:

a) Developing familiarity with a range of common chemical engineering equipment through experiments on pilot-scale apparatus
b) Acquiring or expanding abilities to take a novel project assignment, define an investigation, design and construct experimental apparatus, collect and analyze data, and present conclusions and recommendations in oral or written formats

Brief List of Topics:

a) Formal Experiments
   a. Distillation
   b. Heat Exchanger

    c. Humidification – Air-water contactor
    d. Pump Characterization
b) Reactors
    a. Mixed Tank Cascade
    b. Tubular reactor
c) Informal Experiments (4 open-ended, multi-day assignments)
d) Oral Presentation

CBE 426 - Mass Transfer Operations

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: CHAVEZ-CONTRERAS, RAFAEL

Textbook: McCage, Smith, and Harriott, Unit Operations of Chemical Engineering, 7th ed., McGraw-Hill, 2005.

Supplemental Material:
Mass Transfer: Fundamentals and Applications A.L. Hines and R. N. Maddox

Catalog Description:
Analysis of chemical engineering operations involving mass transfer. Differential and stagewise separation processes; simultaneous heat and mass transfer; mass transfer accompanied by chemical reaction; general design and operation of mass-transfer equipment.

Prerequisite(s): CBE 311 & 320 with grades of C or better, or cons inst

This Course is: Required

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d) an ability to function on multidisciplinary teams
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning

Specific Course Outcomes:

a) Develop familiarity with major chemical process separations units.
b) Apply appropriate criteria for selecting among alternative separation technologies.
c) Complete design calculations for equilibrium staged separation processes (e.g., distillation, absorption).
d) Complete design calculations for differential contactors.
e) Apply mass transfer fundamentals to calculate rates of mass transfer for practical situations and to identify rate-limiting processes.

Brief List of Topics:

a) Selection of separation technology
b) Phase equilibrium review
c) Single-component absorption - graphical methods
d) Binary distillation - graphical methods
e) Liquid-liquid extraction - graphical methods
f) Multicomponent absorption
g) Multicomponent distillation
h) Review of Fick's law
i) Equation of continuity – applications
j) Mass transfer coefficients
k) Interphase mass transfer
l) Differential contactors
m) Adsorption
n) Simultaneous heat and mass transfer
o) Membrane processes

CBE 430 - Chemical Kinetics and Reactor Design

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: RAWLINGS, JAMES B.

Textbook: J. Rawlings and J. Ekerdt, Chemical Reactor Analysis and Design Fundamentals, 1st ed., Nob Hill, 2004.

Supplemental Material:
C. G. Hill, Jr., Introduction to Chemical Engineering Kinetics and Reactor Design, Wiley, 1977

Catalog Description:
Analysis and interpretation of kinetic data and catalytic phenomena; application of basic engineering principles to chemical reactor design.

Prerequisite(s): CBE 311 & 320; or cons inst

This Course is: Required

Specific ABET Outcomes:
- a) an ability to apply knowledge of mathematics, science, and engineering
- b) an ability to design and conduct experiments, as well as to analyze and interpret data
- c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- e) an ability to identify, formulate, and solve engineering problems
- f) an understanding of professional and ethical responsibility
- g) an ability to communicate effectively
- h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:
- a) To develop the ability to analyze kinetic data and determine rate laws
- b) To obtain the ability to apply ideal reactor models
- c) To provide meaningful experience in solving mass and energy balances for chemical reactors
- d) To develop the ability to analyze the performance of reactors in which multiple reactions are occurring
- e) To develop the ability to analyze non-ideal flow conditions in reactors and to develop the skill to utilize simple models to characterize the performance of such reactors

f) To obtain the ability to analyze data for heterogeneous catalytic reactions and to employ the results of such analyses in designing simple reactors
g) To develop the ability to analyze situations in which heterogeneous reactions are limited by diffusion or mass transfer processes

Brief List of Topics:

a) Review of thermodynamics and basic concepts
b) Analysis of kinetic data
c) Theoretical foundations of chemical kinetics (reaction mechanisms, collision theory, transition state theory, explosions)
d) Analysis of complex reaction networks
e) Design of ideal isothermal reactors
f) Selectivity and optimization
g) Temperature and energy effects
h) Non-ideal reactors/residence time considerations
i) Adsorption and heterogeneous catalysis
j) Role of mass transfer phenomena in catalytic reactions

CBE 440 - Chemical Engineering Materials

Credits: 3 **Contact Hours:** 2.5

Course Coordinator: KUECH, THOMAS F

Textbook: White, Physical Properties of Materials, 2nd ed., CRC Press, 2012.

Supplemental Material:
Ralls, Courtney, and Wulff, Introduction to Materials Science and Engineering, Wiley & Sons, 1976

Catalog Description:
Structure and properties of metallic and nonmetallic materials of construction; interrelations between chemical bonding, structure, and behavior of materials.

Prerequisite(s): Chem 345

This Course is: Selected Elective

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:

a) Provide a survey of materials properties
b) Establish the connection of microscopic and chemical principles with macroscopic and physical properties
c) Study the structure and properties of metallic and nonmetallic materials of construction
d) Understand the interactions between chemical bonding, structure, and behavior of materials

Brief List of Topics:

a) Elements, compounds, and bonding
b) Solid structure, crystallography, X-ray diffraction
c) Phase equilibria and transformations

d) Electrical, thermal, and magnetic properties
e) Metals, inorganic materials, polymers, and composites
f) Structural imperfections: defects, dislocations, grain boundaries
g) Mechanical properties: deformation, strength and fracture, creep and relaxation
h) Interfacial phenomena: surface tension, contact angles, wetting, lubrication
i) Optical properties: index of refraction, fiber optics, lasers
j) Materials processing techniques, materials safety data sheets (MSDS), ASTM tests

CBE 450 - Process Design

Credits: 3 **Contact Hours:** 4.7

Course Coordinator: SWANEY, ROSS E

Textbook: Ulrich and Vasudeva, Chemical Engineering Process Design and Economics: A Practical Guide, 2nd ed., Process Publishing, 2004.
Recommended: Towler and Sinnott, Chemical Engineering Design, Second Edition: Principles, Practice and Economics of Plant and Process Design, Butterworth-Heinemann, 2012.

Supplemental Material:
Extensive supplementary reference list

Catalog Description:
Analysis and design of chemical processing systems and equipment.

Prerequisite(s): CBE 326, 426 & 430 or cons inst

This Course is: Required

Specific ABET Outcomes:

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

Specific Course Outcomes:

a) Provide a survey of materials properties
b) Establish the connection of microscopic and chemical principles with macroscopic and physical properties
c) Study the structure and properties of metallic and nonmetallic materials of construction
d) Understand the interactions between chemical bonding, structure, and behavior of materials

e) Development of system design skills for chemical processes
f) Experience solving a complex engineering design problem
g) Ability to perform economic evaluation of chemical processes and capital projects, and economic optimization of designs
h) Familiarity with professional conventions and formats for representing engineering results
i) Integrated application of chemical engineering knowledge acquired in prior courses

Brief List of Topics:

a) Economic Analysis
b) Process Synthesis
c) Shortcut and computer-aided design methods
d) Optimization
e) Risk and safety
f) Design project

CBE 470 - Process Dynamics and Control

Credits: 3 **Contact Hours:** 6.3

Course Coordinator: RAWLINGS, JAMES B

Textbook: "Process Dynamics, Modeling and Control" by B.A. Ogunnaike and W.H. Ray, Oxford Press, 1994.

Supplemental Material: Laboratory Manual

Catalog Description:
A systematic introduction to dynamic behavior and automatic control of industrial processes; lab includes instrumentation, measurement and control of process variables by using conventional hardware and real-time digital computers.

Prerequisite(s): CBE 326; CBE 430 or con reg

This Course is: Required

Specific ABET Outcomes:

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

Specific Course Outcomes:
Objective 1: Introduce undergraduate chemical engineers to dynamics and control of chemical processes. Individual outcomes include:

a) Ability to identify, formulate, and solve linear chemical process dynamics problems.
b) Ability to use techniques, skills, and modern engineering tools necessary for the practice of chemical engineering. Computational tools especially are emphasized in this course.
c) Ability to design and conduct laboratory experiments, as well as to analyze and interpret data, in particular to determine the efficacy of control designs.

d) Ability to design a control system to meet desired needs for a given process.
e) Capacity for continuing development in understanding and expertise in process dynamics and control.

Objective 2: The course is evenly divided between modeling and analysis of chemical process dynamic behavior, and design and analysis methods for automatic control. Individual outcomes include:

a) Understanding of professional and ethical responsibility, including knowledge of contemporary issues, particularly those of safety and environmental impact that are directly affected by control system design.
b) Ability to function on multi-disciplinary teams, and ability to communicate effectively, through laboratory experience, teamwork, and laboratory project reports.

Brief List of Topics:

a) Linear system dynamics
b) Block diagrams, feedback control
c) Process identification
d) Stability: Routh criterion, root locus, Bode, Nyquist
e) Tuning: Xiegler-Nichols, Cohen&Coon
f) Cascade control
g) Feedforward control
h) Multivariable control: linear systems, feedback, interaction, loop pairing, interaction compensation
i) Time delay compensation
j) Discrete time systems
k) Ratio control, overrides, selectors, adaptive control
l) Model-based control

CBE 540 - Polymer Science and Technology

Credits: 3 **Contact Hours:** 2.5

Course Coordinator: LYNN, DAVID M

Textbook: Young and Lovell, Introduction to Polymers, 3rd ed., CRC/Taylor Francis, 2011.

Supplemental Material:

Young, R. A., and Lovell, P. A., "Introduction to Polymers," Second Edition, Chapman and Hall, 1991.

Catalog Description:

Synthesis, properties, and fabrication of plastic materials of industrial importance.

Prerequisite(s): Chem 345; CBE 326 & 430, or con reg; Stat 324; or cons inst

This Course is: Selected Elective

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
e) an ability to identify, formulate, and solve engineering problems
f) an understanding of professional and ethical responsibility
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Specific Course Outcomes:

a) To acquire fundamental chemical and physical information on the synthesis, production and characterization of polymer materials
b) To appreciate the breadth of polymer properties and applications, and to learn in depth about polymers in a particular application area

Brief List of Topics:

a) Polymerization and reactions of polymers - condensation, addition, copolymerization, novel reactions
b) Structure and properties of polymers - polymer solution thermodynamics, measurement of molecular weight and size, morphology and order in crystalline & amorphous polymers, polymer flow and rheology, laboratory equipment and demonstration
c) Polymer processing and fabrication - film and molding technology, fiber

technology, laboratory equipment and demonstration

d) Commercial polymers (production and applications) - olefins, dienes, vinyl and vinylidene polymers and copolymers, heterochain polymers, fluorocarbon polymers, specialty polymers, laboratory equipment and demonstration

CBE 544 - Processing of Electronic Materials

Credits: 3 **Contact Hours:** 2.5

Course Coordinator: KUECH, THOMAS F

Textbook: "The Science and Engineering of Microelectronic Fabrication", by Stephen A. Campbell, Oxford University Press, USA; 2nd edition

Supplemental Material: Literature articles and posted handouts.

Catalog Description:
Physics and chemistry principles underlying microelectronic materials processing. Effects of processing on materials and structures important in microelectronic and opto-electronic devices.

Prerequisite(s): CBE 440 or MS&E 351 or ECE 335; or cons inst

This Course is: Selected Elective

Specific ABET Outcomes:

a) an ability to apply knowledge of mathematics, science, and engineering
c) an ability to design a system, component, or process to meet desired needs
e) an ability to identify, formulate, and solve engineering problems
g) an ability to communicate effectively
h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
l) ability to solve a wide variety of problems in subject areas within which chemical engineers frequently practice, also including associated process hazards.

Brief List of Topics:
This course will study:

a) the basic chemical\physical processing techniques used to synthesize, form and modify materials and structures.

b) The relation between the properties of a deposited or surface modified structures and the process will be developed. The underlying physical and chemical features common too many of these processes will be emphasized.

c) The techniques developed for the both Si and compound semiconductor-based technologies now extending to new materials and applications will be discussed including: materials synthesis, purification, crystallization, physical deposition, optical, e-beam and soft-lithography, chemical vapor deposition, dielectric formation, etching processes, epitaxial growth, plasma processes, and packaging materials.

CBE 547 - Introduction to Colloid and Interface Science

Credits: 3 **Contact Hours:** 2.5

Course Coordinator: ABBOTT, NICHOLAS L

Textbook: Principles of Colloid and Surface Chemistry, 3rd edition, by P. C. Hiemenz and R. Rajagopalan, Marcel-Dekker, New York (1997).

Supplemental Material: None

Catalog Description:
Introduction to topics in colloid and interface science.
Topics include: sedimentation and diffusion, solution thermodynamics, rheology, light scattering, surface tension and contact angle, adsorption, association colloids, particle interactions, electrokinetics, and colloidal stability.

Prerequisite(s): Chem 561 or 562 or equiv, or cons inst

This Course is: Selected Elective

Specific ABET Outcomes:
a) an ability to apply knowledge of mathematics, science, and engineering
b) an ability to design and conduct experiments, as well as to analyze and interpret data
e) an ability to identify, formulate, and solve engineering problems
i) a recognition of the need for, and an ability to engage in life-long learning
j) a knowledge of contemporary issues
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Brief List of Topics:
a) Introduction to colloids and interfaces
b) Sedimentation and diffusion
c) Osmotic pressure
d) Rheology
e) Light scattering
f) Surface tension and contact angle
g) Adsorption
h) Micelles and emulsions
i) van der Waals forces
j) Electrostatic forces
k) Electrokinetics
l) Colloidal stability

BIOCHEMISTRY 501 - Introduction to Biochemistry

Credits: 3 **Contact Hours:** 2.5

Course Coordinator: Dr. Kelley Harris-Johnson

Textbook: Lehninger Principles Of Biochemistry, Nelson/Cox, 2008 (5th Ed)

Supplemental Material: The Absolute Ultimate Guide To Lehn. Principles Of Biochemistry Study Guide And Solutions Manual, Osgood & Ocorr, 2008
MacMillan iClicker (ISBN: 0-7167-7939-0) is required

Catalog Description:
Chemistry, nutrition, and metabolism of biological systems.
Not accepted toward departmental M.S. or Ph.D. degree.

Prerequisite(s): Chem 341 or 343

This Course is: Selected Elective

Topics Covered:

- Structural and Catalytic Components of Cells
  - Amino acids
  - Proteins
  - Enzymes
  - Structure and properties of lipids
- Energy Production: Catabolism and Bioenergetics
  - Thermodynamics and Bioenergetics
  - Glycolysis
  - Photosynthesis
  - Metabolism and Evolution
- Biosynthesis and metabolic regulation
  - Synthesis of fatty acids and phospholipids
  - Regulation of blood glucose
  - Biosynthesis of amino acids and porphyrins
  - Integration of metabolism
- Information Transfer
  - DNA and Chromosome Structure
  - DNA replication
  - Mutagenesis
  - Gene regulation
  - RNA processing

CHEMISTRY 109 - Advanced General Chemistry

Credits: 5 **Contact Hours:** 6.3

Course Coordinator: Engelkemier, Joshua Michael

Textbook: Chemistry: The Molecular Science, Moore, Stanitski, Jurs, 2010 (4^{th} Ed)

Supplemental Material: Chemistry 109 Laboratory Manual, Fall 2010
Safety goggles also required

Catalog Description:
A modern introduction to chemical principles that draws on current research themes. For students with good chemistry and math background preparation who desire a one-semester coverage of general chemistry.
Recommended for students intending majors in chemistry or allied fields.
Lecture, lab, and discussion.

Prerequisite(s): 1 yr HS chem, 3 yr HS math; suitable math placement score. Open to Fr. Only 4-5 credits from Chem 103, 108, & 109 will be accepted for degree credit

This Course is: Required

Course Goals: Chemistry 109 is a one-semester, accelerated, first-year college course in chemistry. The goals of this course are: 1) to build your skills in problem solving, analytical reasoning, and laboratory manipulation, and 2) to build your knowledge of the fundamental chemical principles of atomic and molecular structure, kinetics, and thermodynamics. In this class we will apply these principles to condensation-hydrolysis reactions, acid-base reactions, and oxidationreduction reactions. We will emphasize applications in living organisms (for example in drug design), and in the industrial world (for example in fuel production and utilization).

Topics Covered:
- Atoms, Molecules, and Chemical Reactions
- Chemical Bonding
- Solids, Liquids, and Solutions
- Thermodynamics
- Covalent Bonding
- Properties of Organic Compounds and other Covalent Substances
- Synthetic Polymers
- Molecules in Living Systems
- Chemical Kinetics
- Entropy and Spontaneous Reactions
- Chemical Equilibrium
- Ionic Equilibria in Aqueous Solutions

CHEMISTRY 329 - Fundamentals of Analytical Science

Credits: 4 **Contact Hours:** 10.7

Course Coordinator: Richards, Alicia Leigh

Textbook: Quantitative Chemical Analysis, Daniel Harris, 2010 (8^{th} Ed)

Supplemental Material: None

Catalog Description:
Fundamentals of chemical measurement in chemistry, biology, engineering, geology, and the medical sciences.
Topics include equilibria of complex systems, spectroscopy, electrochemistry, separations, and quantitative laboratory technique.
For chemistry majors, chemical engineering majors, and related majors.
Lecture, lab, and discussion.

Prerequisite(s): Chem 104, 109 or cons inst

This Course is: Required

Topics Covered:
- Equilibria of complex systems
- Spectroscopy
- Electrochemistry
- Separations
- Quantitative laboratory technique

CHEMISTRY 343 - Introductory Organic Chemistry

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: Hershberger, John C

Textbook: Organic Chemistry, Loudon, 2009 (5th Ed)

Supplemental Material: Organic Chemistry Student Solution Manual by Loudon and Stowell

Catalog Description: Introductory Organic Chemistry

Prerequisite(s): For students expecting to take 2 semesters organic chemistry; Chem 104 or 109. Not for credit for those who have taken Chem 341

This Course is: Required

Topics Covered:

- Periodic Trends and Bonding
- Hybridization
- Alkanes
- Acid/Base Chemistry
- Stereoisomers
- Substitutions
- Eliminations
- Ether Synthesis
- Alkynes/Alkenes
- Epoxides
- Grignard Reaction
- Oxidation
- Ozonolysis
- Radical Halogenation
- Aromaticity

CHEMISTRY 344 - Introductory Organic Chemistry Laboratory

Credits: 2 **Contact Hours:** 1.7

Course Coordinator: Foarta, Floriana Andreea

Textbook: No textbook is required. Laboratory manual created by instructor

Supplemental Material: Laboratory notebook is recommended. Eye protection is required.

Catalog Description: Basic analytical techniques for organic chemistry. Commonly used synthetic methods. Purification and characterization of reaction products.

Prerequisite(s): Credit or con reg in Chem 345

This Course is: Required

Course Goals: The goal of the course is to teach techniques of experimental organic chemistry. The first half of the course introduces routinely used separation, purification and identification techniques and laboratory exercises and demonstration experiments. The second half of the course consists of experiments demonstrating standard synthetic methods.

CHEMISTRY 345 - Intermediate Organic Chemistry

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: Amberger, Brent Kindblom

Textbook: Organic Chemistry, Loudon, 2009 (5^{th} Ed)

Supplemental Material: Organic Chemistry Student Solution Manual, Loudon, is recommended. Also recommended is the Organic Model Kit sold by UW Chem Dept.

Catalog Description: Intermediate Organic Chemistry

Prerequisite(s): Chem 343 with grade of C or better

This Course is: Required

Topics Covered:
- Infrared Spectroscopy and Mass Spectrometry
- Nuclear Magnetic Resonance Spectroscopy
- Chemistry of Benzene
- Allylic and Benzylic Reactivity
- Aryl Halides and Phenols
- Aldehydes and Ketones
- Carboxylic Acids
- Carboxylic Acid Derivatives
- Enolate Ions and Unsaturated Carbonyl Compounds
- Amines
- Carbohydrates
- Aromatic Heterocycles
- Amino Acids, Peptides and Proteins

CHEMISTRY 562 - Physical Chemistry

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: Preston, Thomas Joel

Textbook: Physical Chemistry Vol 2: Quantum Chemistry, Atkins and Paula, 2010 (9th Ed)

Supplemental Material: None

Catalog Description: Molecular theory: quantum chemistry, molecular structure and spectra, statistical mechanics, selected topics in the molecular theory of matter in bulk.

Prerequisite(s): Chem 561 or 565 or CBE 310; Physics 202 or 208

This Course is: Required

Course Goals: This course discusses the microscopic view of matter and chemical phenomena using the tools of quantum mechanics and statistical mechanics. It is structured for students who have had a year of calculus and a year of physics. The goal is to provide the physical and mathematical underpinnings of a molecular description of physical and chemical properties.

Topics Covered:
- Fundamentals of Quantum Mechanics
- Rotational and Vibrational Spectroscopy
- Quantum Mechanics of Atoms
- Chemical Bonds (Molecules)
- Electronic Spectroscopy
- Stastical Thermodynamics
- Molecular Reaction Dynamics

GENETICS 466 – General Genetics

Credits: 3 **Contact Hours:** 2.5

Course Instructor: Qiang Chang

Textbook: Introduction to Genetic Analysis, Griffiths, Wessler, Lewontin and Carroll, 2008 (9^{th} Ed).

Supplemental Material: Introduction to Genetic Analysis Solutions Megamanual, Fixsen, Lavett, and Young, 2008 (9^{th} Ed)

Catalog Description: Genetics in eukaryotes and prokaryotes. Includes Mendelian genetics, mapping, molecular genetics, genetic engineering, cytogenetics, quantitative genetics, and population genetics. Illustrative material includes viruses, bacteria, plants, fungi, insects, and humans.

Prerequisite(s): Algebra, 1 yr chem & 1 yr biology or cons inst

This Course is: Selected Elective

Topics Covered:
- Genes, Chromosomes, and Linkage
    - Cell Cycle, Mitosis, and Meiosis
    - Probability for Genetic Events
    - Chromosome—Number and Rearrangements
    - Linkage and Mapping
- Molecular Biology of the Gene
    - DNA replication
    - Transcription
    - Translation and genetic code
    - Bacterial genetics
    - Epigenetics
- Population and Evolutionary Genetics
    - The Gene Pool Concept
    - Genetic Drift
    - Natural Selection
    - Nature versus Nurture
    - Genetics of Plant and Animal Breeding

MATHEMATICS 221 - Calculus and Analytic Geometry 1

Credits: 5 **Contact Hours:** 4.2

Course Coordinator: Sigurd Angenent

Textbook: Thomas' Calculus 12th Edition, Thomas,Weir,Hass, 2009 (12th Ed)

Supplemental Material: None

Catalog Description: Introduction to differential and integral calculus and plane analytic geometry; applications; transcendental functions.

Prerequisite(s): I) Advanced math competency-algebra & suitable placement scores, or Math 112 & (II) Advanced math competency-trigonometry & suitable placement scores, or Math 113; or Math 114. Open to Freshmen

This Course is: Required

Topics Covered:

- Coordinates, lines, circles
- Functions and graphing, trig functions
- Limits, intuitively and with an idea of how they can be formalized, including limits at infinity and infinite limits, trig limits
- Derivatives, Chain rule, Leibniz notation, higher order derivatives, implicit differentiation, related rates, approximations
- Applications of the derivative
- Antiderivatives, indefinite integrals and introduction to differential equations
- Sums, areas and the definite integral. Fundamental Theorem of Calculus.
- u-substitution, applications of the integral: areas and volumes.
- Transcendental functions, limits involving logs, exp and powers. Optional: Hyperbolics functions.

MATHEMATICS 222 - Calculus and Analytic Geometry 2

Credits: 5 **Contact Hours:** 1.7

Course Coordinator: Sigurd Angenent

Textbook: Thomas' Calculus 12th Edition, Thomas,Weir,Hass, 2009 (12th Ed)

Supplemental Material: None

Catalog Description: Techniques of integration, first order ordinary differential equations, conic sections, polar coordinates, vectors, two and three dimensional analytic geometry, infinite series.

Prerequisite(s): Math 221. Open to Freshmen

This Course is: Required

Topics Covered:

- Techniques of integration: substitution, integration by parts, trigonometric integrals, trigonometric substitutions, partial fraction decompositions, improper integrals
- Applications of integration to arc length, moments and center of mass, pressure and force, and elementary differential equations
- Definitions and relations between infinite sequences and series, algebraic and geometric series
- Convergence tests for series: integral, comparison and ratio tests. Absolute convergence and alternating series
- Power series and radius of convergence
- Taylor and Maclaurin series. Taylor's formula, exp, cosine and sine expansions
- Error bounds for Taylor approximations
- Differential equations, linear first order
- Linear second order and free vibrations
- Polar coordinates, and finding areas in polar coordinates
- Vectors and parametric equations
- Products, lines and planes
- Velocity and acceleration. Tangent vectors and arc-length
- Normal and curvature
- Dot and cross products and their differentiation.
- Vectors and vector functions in Polar coordinates
- Planetary motion

MATHEMATICS 234 - Calculus--Functions of Several Variables

Credits: 4 **Contact Hours**: 3.3

Course Coordinator: Sigurd Angenent

Textbook: Thomas' Calculus 12^{th} Edition, Thomas,Weir,Hass, 2009 (12^{th} Ed)

Supplemental Material: None

Catalog Description: Introduction to calculus of functions of several variables; calculus on parameterized curves, derivatives of functions of several variables, multiple integrals, vector calculus.

Prerequisite(s): Math 222. Closed to students with credit for Math 223

This Course is: Required

Topics Covered:
- Vector functions and space curves, velocity and acceleration
- Arc length and curvature, normal and binormal
- Motion in space, planetary motion
- Partial derivatives
- Tangent planes and normals
- Linear approximation
- gradient and total differential
- Local and absolute extrema
- Lagrange multipliers
- Higher derivatives, exact differentials
- Double and iterated integrals, including polar coordinates
- Applications of double integrals
- Triple and iterated integrals, including cylindrical and spherical coordinates
- Applications of triple integrals, volume and surface areas.
- Vector fields, surface integrals and line integrals
- Flux, Green's theorem
- Divergence Theorem, Stokes' theorem

MATHEMATICS 319 - Techniques in Ordinary Differential Equations

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: Eyderman,Vladimir

Textbook: Elementary Differential Equations with Boundary Value Problems, Boyce & DiPrima, 2008 (9^{th} Ed)

Supplemental Material: None

Catalog Description: Review of linear differential equations; series solution of linear differential equations; boundary value problems; Laplace transforms; possibly numerical methods and two dimensional autonomous systems.

Prerequisite(s): Math 222

This Course is: Selected Elective

Course Goals: This course presents techniques for solving and approximating solutions to ordinary differential equations. It is primarily for students in disciplines which emphasize methods. Math 319 is a prerequisite for Math 519, an advanced course intended for math majors and others who need a theoretical background in ordinary differential equations or a more detailed study of systems and/or behavior of solutions.

Topics Covered:

- First order equations
    - the basic existence and uniqueness theorem (for first order equations)
    - the Euler scheme and other numerical methods (optional)
- Second order linear equations with constant coefficients
    - inhomogeneous equations via methods of annihilators and variation of parameters
    - remarks on higher order equations, linear independence, and the Wronskian
    - applications to forced oscillation problems, effect of resonances
- Series solutions of linear equations
    - Euler equations
- Laplace transform
    - definition and elementary properties
    - application to constant coefficient linear equations
- First order systems
    - conversion of 2nd and higher order equations to systems
    - differentiation of vector and matrix functions
    - solution of linear constant coefficient systems

MATHEMATICS 320 - Linear Algebra and Differential Equations

Credits: 3 **Contact Hours:** 2.5

Course Coordinator: Hernandez-Duenas,Gerardo

Textbook: Differential Equations and Linear Algebra, Edwards and Penney, 2007 (3rd Ed)

Supplemental Material: None

Catalog Description: Introduction to linear algebra, including matrices, linear transformations, eigenvalues and eigenvectors. Linear systems of differential equations. Numerical aspects of linear problems.

Prerequisite(s): Math 222

This Course is: Selected Elective

Course Goals: Differential equations are the fundamental tools that modern science and engineering use to model physical reality. The importance of differential equations to these disciplines cannot be overemphasized. A distinct subject in its own right, linear algebra is a part of mathematics concerned with the structure inherent in mathematical systems. We shall study these subjects together for three reasons: (1) The viewpoint of linear algebra is immensely helpful in uncovering the order underlying the topic of differential equations; it helps us understand the ``why'' and not just the ``how'' of our calculations. (2) Linear algebra is essential to the theory of differential equations. And (3) linear algebra is crucial to the computer approximations which are often the only way to solve the most challenging differential equations.

Topics Covered:
- First-Order ODEs
- Mathematical Modeling and Numerical Methods
- Linear Systems and Matrices
- Vector Spaces
- Higher-Order Linear ODEs
- Eigenvalues and Eigenvectors
- Linear Systems of ODEs
- Matrix Exponential Methods (to solve non-homogeneous systems)
- Nonlinear Systems

MICROBIOLOGY 303 - Biology of Microorganisms

Credits: 3 **Contact Hours:** 3.5

Course Coordinator: Kaspar, Charles

Textbook: Microbiology, an Evolving Science, Slonczewski & Foster, 2010 (2^{nd} Ed)

Supplemental Material: None

Catalog Description: Basic biology of prokaryotic microorganisms, including structure, function, physiology genetics and ecology of bacteria.

Prerequisite(s): Previous course in botany, zoology, biocore or general biology;
1 semester organic chemistry or concurrent registration.

This Course is: Selected Elective

Course Goals:

- To understand the importance of microbes to the natural world and to your life
- To learn the fundamentals of the discipline: microbial form and function, bacterial physiology, microbial ecology, virology, bacterial genetics, immunology and pathogenic microbiology.
- To learn the applications of microbial concepts to the fields of nutrition, biotechnology, medicine, agronomy and bioremediation.
- To understand the diversity of the microbial world.

Topics Covered:

- Origins, taxonomy, and evolution of microbiology
- Microbial diversity and ecology
- Mutualism to pathogenesis
- Microbial diseases and epidemiology
- Cell structure and function
- Energy generation: chemical-driven and light driven
- Metabolism: catabolism and anabolism
- Central Dogma
- Genetic code, translation, and protein structure
- Bacteriophage and viruses
- Global regulation strategies, methods, and rationale
- Biotechnology

PHYSICS 201 - General Physics

Credits: 5 **Contact Hours:** 6.3

Course Coordinator: Chehade, Abdallah Adnan

Textbook: Physics for Scientists & Engineers, Serway & Jewett, 2009 (8^{th} Ed)

Supplemental Material: Lab Manual

Catalog Description: Primarily for engineering students. Mechanics and heat.
Two lectures, two discussions and one three-hour lab per week.

Prerequisite(s): Math 211 or 221 or 1 yr HS calc or cons inst. Not open to students who have had Physics 207. Degree credit will not be given for both Physics 103 & 201. Open to Fr

This Course is: Required

Course Goals:

1. To understand basic principles (e.g. Newton's Laws) and their consequences (e.g. conservation of momentum, etc.)
2. To solve problems using both quantitative and qualitative applications of these physical principles.
3. To develop an intuition of the physical world.
4. To prepare students for the application of physics to topics not explicitly covered by courses.
5. To characterize physical observations quantitatively and understand its statistical significance.

Topics Covered:

- Laws of Motion
- Energy and Energy Conservation
- Rotation and Angular Momentum
- Static Equilibrium and Elasticity
- Gravitation
- Oscillations

PHYSICS 202 - General Physics

Credits: 5 **Contact Hours:** 6.3

Course Coordinator: Agarwal, Deepak

Textbook: Physics for Scientists & Engineers, Vol 2, Serway & Jewett, 2010 (8th Ed)

Supplemental Material: Lab Manual

Catalog Description: Primarily for engineering students. Electricity, magnetism, light, and sound. Two lectures, two discussions and one three-hour lab per week.

Prerequisite(s): Physics 201 or equiv. Not open to students who have had Physics 208. Degree credit will not be given for both Physics 104 & 202. Open to Fr

This Course is: Required

Course Goals:
Physics 202 is the second semester of a 2-semester introduction to physics that is designed mainly for engineering students. The main topics are electricity, magnetism, light, optics, and sound. There are two lectures, two discussions and one three-hour lab per week. Our goal is to help you develop an understanding and intuition for physics so that you can solve practical problems. The way to accomplish this goal is by thinking about and solving lots of problems and experimenting in the lab. We hope that Physics 202 will develop the critical thinking and collaborative skills you will need in your future career.

Topics Covered:
- Electrostatics
- Gauss's Law
- Capacitors & Dielectrics
- Electric Current
- Magnetic Force and Magnetic Fields
- Electromagnetic Waves
- Light Reflection & Refraction
- Interference
- Diffraction

STATISTICS 324 - Introductory Applied Statistics for Engineers

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: Tao, Minjing

Textbook: Principles of Statistics for Engineers and Scientists, Navidi, 2009 (1st Ed)

Supplemental Material: None

Catalog Description: Introductory Applied Statistics for Engineers

Prerequisite(s): Math 222. Students may receive degree credit for no more that one of the following: Stat 201, 224, 301 and 324. Open to Fr

This Course is: Required

Course Goals: Descriptive statistics, probability concepts and distributions, random variables. Hypothesis tests and confidence intervals for one- and two-sample problems. Linear regression, model checking, and inference. Analysis of variance and basic ideas in experimental design.

Topics Covered:
- Mean, Variance, Median, Quartiles, IQR
- Reliability Analysis
- Mean and Standard Deviation (discrete and continuous)
- Binomial Distribution
- Regression
- Prediction Intervals
- Factorial Experiments

ZOOLOGY 153 - Introductory Biology

Credits: 3 **Contact Hours:** 3.3

Course Coordinator: Fu,Qiang

Textbook: Biology, Campbell and Reece, 2010 (9^{th} Ed)

Supplemental Material: iClicker is also required

Catalog Description: One-semester course designed for majors in chemical and biological engineering and other engineering disciplines. Topics include: cell structure and function, cellular metabolism (enzymes, respiration, photosynthesis), information flow (DNA, RNA, protein), principles of genetics, and a survey of the five major kingdoms of organisms.

Prerequisite(s): Open to Fr. Enrollment in an undergraduate engineering degree program. HS chemistry or con reg in college chemistry strongly advised. Not for full credit for those who have taken Bot 100, 130, 151; Zool 101, 120, 151; or equiv

This Course is: Required

Course Goals: Emphasis will be placed on learning, understanding and being able to use key biological concepts and the scientific method. The study of modern biology is not only a matter of assimilating factual information. Learning how to use that information for problem-solving, posing hypotheses and interpreting experimental results is also critical to understanding biology as a science. The lectures examine key concepts. Discussions allow you to more fully investigate these. In the laboratory, you will use the scientific method and apply a number of the concepts from lecture to carry out the various exercises.

Topics Covered:

- Macromolecules
- Membranes
- Cells and Organelles
- Respiration
- Photosynthesis
- Multicellularity
- Cell Division
- DNA and Mutations
- Gene Regulation
- Meiosis and Mendelain Genetics
- Transgenic Technology and Stem Cells
- Population Genetics
- Origin of Species

ZOOLOGY 570 - Cell Biology

Credits: 3 **Contact Hours:** 3.0

Course Coordinator: Amann, Kurt

Textbook: Molecular Cell Biology, Harvey Lodish et al., 6th edition, W.H. Freeman, 2007.

Supplemental Material: None

Catalog Description: Comprehensive course on modern aspects of cell biology

Prerequisite(s): One year College Biology, One year Chemistry

This Course is: Selected Elective

Course Goals:
- To reveal the fascinating world of the eukaryotic cell. Eukaryotic cells are both incredibly complex and extremely well ordered. Students will learn to appreciate the complexity, recognize the order and understand the roles played by growth in the cell.
- Students will be expected to learn facts (e.g., names of important cell components), concepts (e.g., ideas that unify areas of cell biology research) and experimental design (i.e., how to best exploit the scientific method as it applies to cell biology).
- Students will learn to think like scientists in general, and cell biologists in particular, a possibility that I'm sure fills most of you with something like ecstasy.

Topics Covered:
- Pillars of Cell Biology
- DNA Replication
- Transcription/Translation
- General Protein Sorting
- Cotranslational Insertion
- Golgi Sorting
- Regulated Exocytosis
- Endocytosis
- Nuclear Transport
- Actin-associated Proteins and Motility
- Microtubules
- Signaling – Lipid hormones, EGF, Notch/g-protein
- Cell cycle – mechanics, regulation, checkpoints
- Cytokinesis
- Cell Junctions
- Wound Healing

Appendix C – Major Equipment

The Department maintains major laboratory equipment in support of the required undergraduate laboratory courses. These include dedicated facilities and shared, multi-use equipment located in instructional laboratory space and shared between laboratory courses, or with CBE 599 – Independent Study project students. Equipment described below is home-built when no manufacturer name is given.

Distillation column – 28-tray, 8” stainless steel valve-tray column with associated pumps, tanks, and instrumentation

Heat exchanger – 23 ft2 tube-and-shell exchanger with recirculating hot and cold supply tanks, pumps, and measurement instrumentation

Humidification – spray tower for air-water contacting experiment, including industrial blower and associated instrumentation

Pumps – characterization manifold with interchangeable 6” and 4” centrifugal pumps, including multiple flowmeters and instrumentation

Reactors apparatus – Tubular reactor and cascade of three mixed tanks, with instrumentation

Flow experimentation benches (4) – multipurpose modules reconfigurable by students for a range of experiments in CBE 324

Instrumentation Room (for CBE 324, 424, and other lab projects)

Gow-Mac 350 GC (3) – with SpectraPhysics integrators

Waters HPLC – configured for lipids and biodiesel experiments

Dionex HPLC – configured for sugars and biofuels experiments

Perkin-Elmer Plasma 400 ICP-AES – elemental analysis

Balances, tools, and other miscellaneous components for student-built experiments

The Department also has extensive instrumentation and equipment for support of the graduate research program that can be made available for use by undergraduates involved in CBE 599 projects or needing special capabilities for Informal projects in CBE 424 – Operations and Process Laboratory (Summer Lab). This lengthy listing will be available for review at the visit if desired.

APPENDIX D – INSTITUTIONAL SUMMARY

1. The Institution

1.a. Name and address of the institution:
The University of Wisconsin – Madison is located in Madison, Wisconsin.

1.b. The Chief Executive Officer of the institution:
Chancellor David Ward
161 Bascom Hall
500 Lincoln Drive
Madison, WI 53706
(608) 262-9946

1.c. The name and title of the person submitting the self-study report:
Dean Paul S. Peercy
College of Engineering
2610 Engineering Hall
1415 Engineering Drive
Madison, WI 53706
(608) 262-3482

1.d. The organizations by which the institution is now accredited and the dates of the initial and most recent accreditation evaluations:
The Madison campus of the University of Wisconsin was re-accredited by the North Central Association of Secondary Schools and Colleges in Spring 2009. It was first accredited by the NCA in 1913.

2. Type of Control

The University of Wisconsin-Madison is a state supported institution.

3. Educational Unit

The narrative provided below describes the educational unit in which the chemical engineering program is located, including the administrative chain of responsibility from the program, to the department, to the various College faculty committees that oversee curricular improvements, through the Dean of the College of Engineering, through the various Colleges and Schools that comprise the UW-Madison, and culminating with the institutional leadership of the UW-Madison. Figures A.1 and A.2 are administrative organizational charts for the College of Engineering, and the UW-Madison campus, respectively.

The chemical engineering program described in this Self Study is housed within the Department of Chemical and Biological Engineering, led by Department Chair Nicholas Abbott (through June 30, 2012) or incoming Department Chair Thomas Kuech (from July 1, 2012 onward). The departmental representative preparing this ABET Self Study is

Prof. Thatcher Root. As chair of the Assessment Committee, he works closely with the departmental Curriculum Committee, and reports to the Department Chair and the faculty of the program.

The College of Engineering at the University of Wisconsin-Madison houses **nine** academic departments that offer **eleven** Bachelor of Science degree programs, and over three dozen Master of Science, Master of Engineering, and Ph.D. degree programs. The Chief Executive Officer of the College of Engineering is Dean Paul S. Peercy.

In the College of Engineering, department chairs and faculty members make budgetary and curricular adjustments through a variety of different committees. Department chairs meet monthly with the Dean as his Operating Committee to address budgetary concerns, and elected members of each department sit on the Academic Planning Council (APC), which provides oversight on large-scale curricular changes (like proposals for new undergraduate majors, new advanced degree programs, and new certificate programs). Significant curricular changes must also go through the appropriate Divisional Committee at the campus level; typically for the College of Engineering this is the Physical Sciences Divisional Committee.

Individual departments, Colleges, and the campus as a whole continually renew the UW's strong history of shared governance involving faculty, staff, and students. At the campus level, curricular change (and faculty tenure packages) are considered and approved by Divisional Committees, which are elected positions held by faculty in representative departments. The Divisional Committees are an offshoot of the Faculty Senate, which has a major role in the operation of the university. The Faculty Senate is led by the University Committee, an elected faculty body. The academic staff of the university also have a formal role in university governance, and the Academic Staff Assembly serves in a similar capacity for staff as the Faculty Senate does for faculty.

UW-Madison campus is comprised of 14 schools, colleges, and institutes that include 120 academic departments: the College of Engineering; the College of Agricultural and Life Sciences; the School of Business; the School of Education; the School of Human Ecology; the College of Letters and Science; the School of Medicine and Public Health; the School of Nursing; the School of Pharmacy; the Law School; the School of Veterinary Medicine; the Graduate School, the interdisciplinary Gaylord Nelson Institute for Environmental Studies; and the interdisciplinary Wisconsin Institute of Discovery. Apart from the deans and directors who lead these organizations, there is the Dean of Students, the Dean of Continuing Studies, and the Dean of International Studies and Programs.

Interim Chancellor Dr. David Ward is the chief executive of the institution, and he reports to the UW System President, Dr. Kevin Reilly, and the University of Wisconsin Board of Regents. The Chancellor is assisted by the Provost, Paul DeLuca (who also serves as the Vice Chancellor for Academic Affairs), and two other vice chancellors, including the Vice Chancellor for Administration and the Vice Chancellor for Research (who also serves as Dean of the Graduate School).

Two organizational charts follow; Figure D.1 is for the College of Engineering, and Figure D.2 is for the UW-Madison campus.

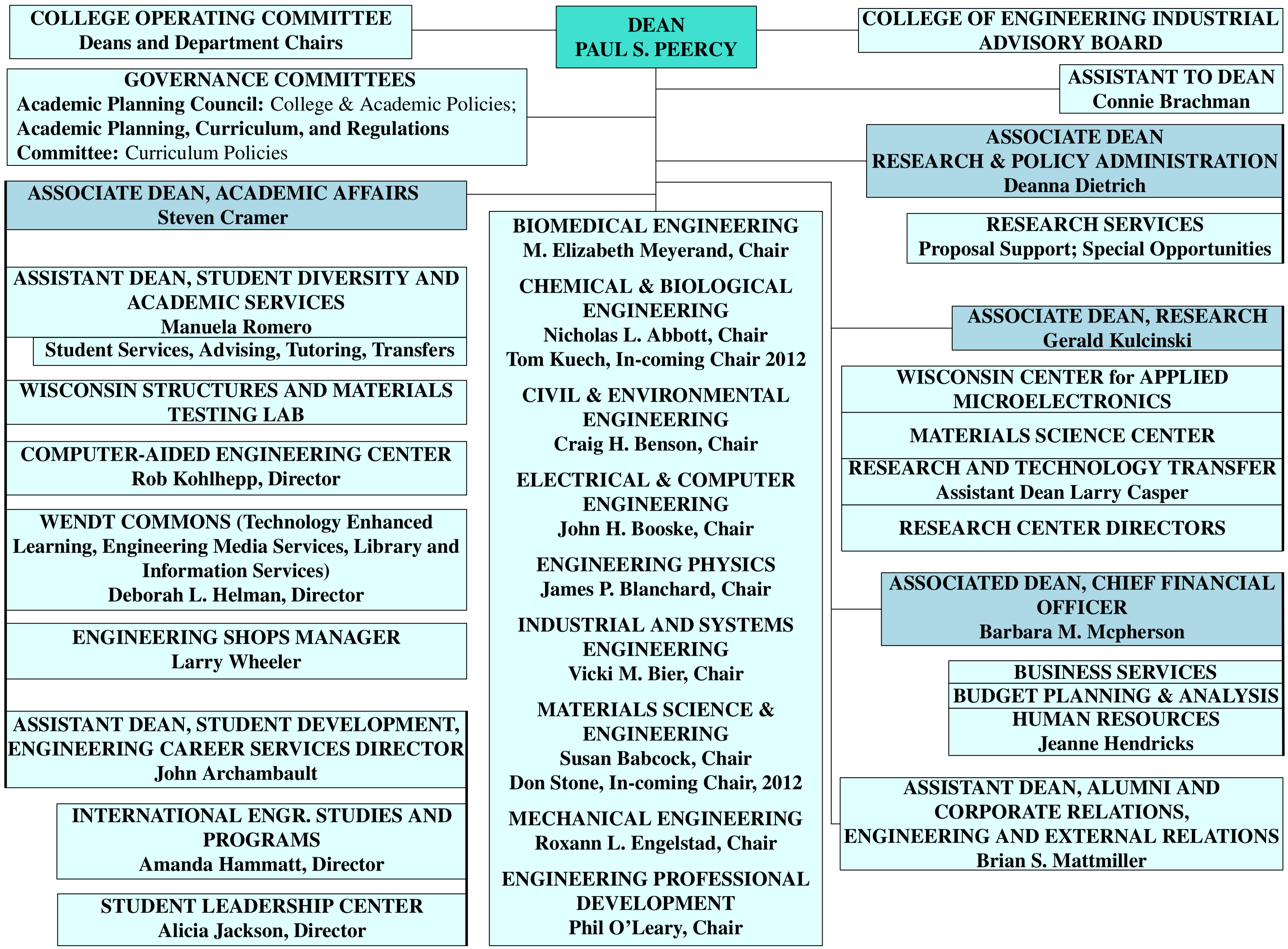

Figure D.1 The Organizational Chart for the College of Engineering.

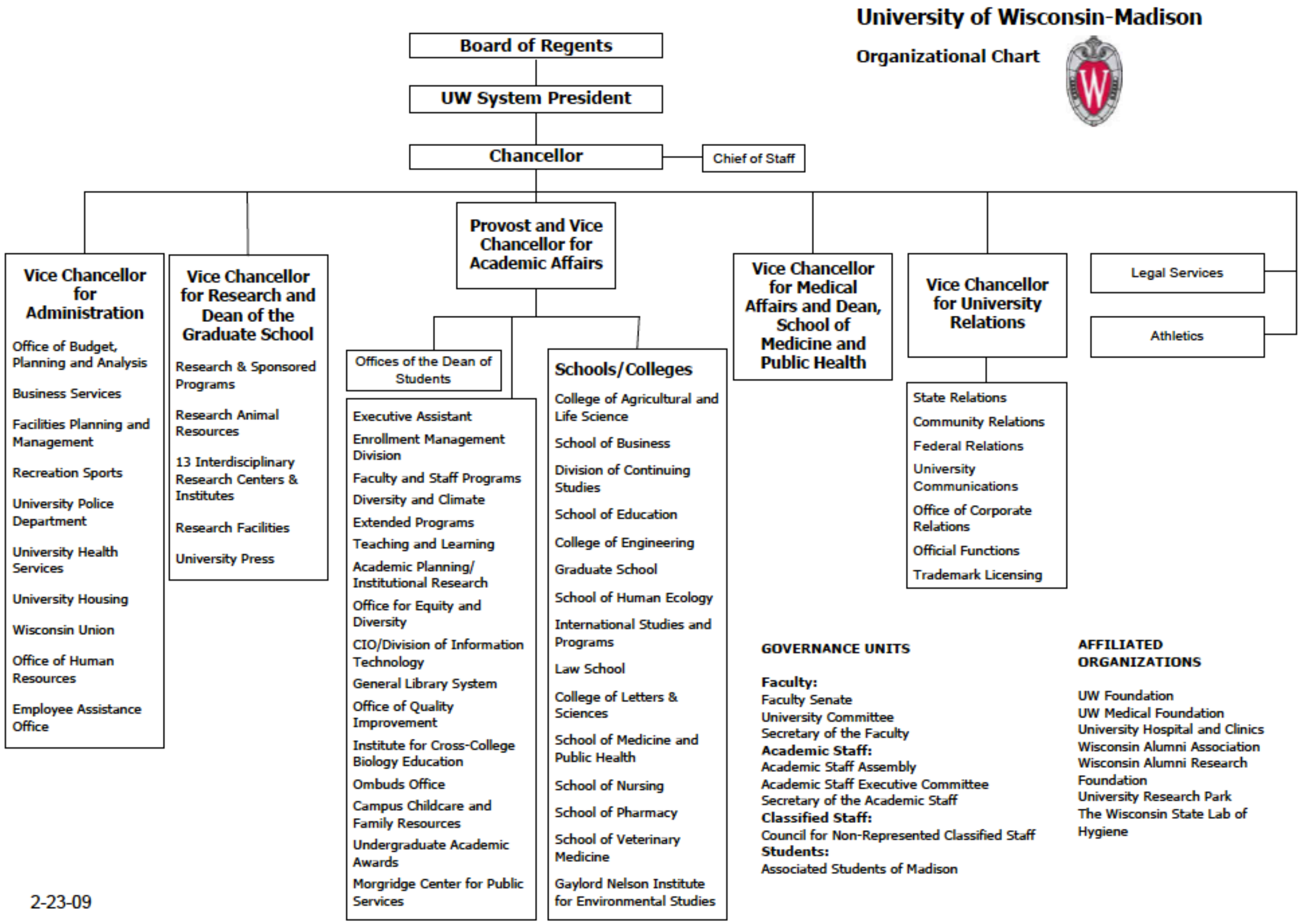

Figure D.2 The Organizational Chart for the University of Wisconsin, Madison

4. *Academic Support Units*

4.1 Academic Support Units Outside of the College of Engineering

Although students may elect to take courses from any academic department on campus, according to a statistical analysis, students in the College of Engineering most heavily on the following 13 departments. Contact information for the Chair of each of these departments is provided below. Additional details are available upon request, and a representative from each of these programs can be available during the site visit, as needed.

Department	Chair of Dept.	Direct phone number	Department website
Chemistry	James C. Weisshaar	(608) 262-8005	chem.wisc.edu
Communication Arts	Michelle Hilmes	(608) 262-2277	commarts.wisc.edu
Economics	John Karl Scholz	(608) 263-2989	econ.wisc.edu
Geoscience	Brad Singer	(608) 265-8650	geology.wisc.edu
Mathematics	Steffan Lempp	(608) 263-1975	math.wisc.edu
Physics	Robert J. Joynt	(608) 263-3279	physics.wisc.edu
Statistics	Brian Yandell	(608) 262-1157	stat.wisc.edu
English	Theresa Kelley	(608) 263-3765	wisc.edu/english/
History	Flo. E. Mallon	(608) 263-1808	hist.wisc.edu
Computer Science	Jeffrey Naughton	(608) 262-8737	cs.wisc.edu
Anthropology	J. Mark Kenoyer	(608) 262-7395	anthropology.wisc.edu
Physiology/ Neuroscience	Tom Yin	(608) 262-2938	physiology.wisc.edu
Zoology	Jeff D. Hardin	(608) 262-1051	zoology.wisc.edu

The table includes departments that offer courses to meet General Education requirements for all UW undergraduates, particularly in liberal studies and ethnic studies. Since literally hundreds of courses are available that meet the liberal or ethnic studies requirement, we have not attempted to show all of the different departments that offer those courses; instead, we performed a statistical analysis of enrollments in the past six years, and we found that Communication Arts, English, History, and Anthropology were the departments that offer the electives our students take most frequently. Thus, their contact information is provided above.

4.2 Academic Support Unit: Technical Communication Program

Housed in the College of Engineering, the Technical Communication Program (TC Program), within the department of Engineering Professional Development, delivers required courses in technical communication for undergraduate engineering students, so it is a key academic support unit for many engineering programs. The TC program offers the required communication courses for undergraduates and graduate students, and a 24-credit Certificate program in Technical Communication. The tiered undergraduate courses in Basic and Technical Communication (EPD 155 and 397) meet the **University's General Education Requirements** as well as engineering major requirements for professional communication practices. This program assists the undergraduate programs in the College of Engineering in meeting ABET accreditation requirements by assessing the following six ABET student outcomes:

- d. an ability to function on multidisciplinary teams
- f. an understanding of professional and ethical responsibility
- g. an ability to communicate effectively
- h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- i. a recognition of the need for, and an ability to engage in life-long learning
- j. a knowledge of contemporary issues

The two General Education Communication Requirement courses EPD 155 and EPD 397 provide foundational and advanced communication knowledge. After completing the basic communication course EPD 155, students have demonstrated skills in critical reading and writing as well as foundational abilities in writing, public speaking, and teamwork. Students take EPD 155 in their first year; some programs require a sophomore-level technical presentations course (EPD 275). In the junior year, students take EPD 397, Technical Communication, a 3-credit course. After completing EPD 397, students are prepared to write major proposals and reports, work with technical source materials, give professional presentations using current presentation technology, and collaborate on written and oral engineering projects. Analyses of case studies help students understand the impact of engineering solutions in society as well as their professional and ethical responsibilities.

Since the main mission of the TC Program is effective teaching of communication for COE undergraduate students, a great deal of time is committed to effective pedagogy, collaboration across the departments in COE, and meaningful assessment strategies. In particular, the EPD 397 course has been rigorously assessed since Fall 2005 for ABET purposes. Longitudinal data has been gathered and assessed for student outcomes (d), (f), (g), and (i) since Fall 2005, and more specific performance indicator data for all of these outcomes plus (h) and (j) were gathered in Fall 2011. All of this data and student samples for each program undergoing re-accreditation will be available at the onsite ABET visit.

The main TC mission is effectively teaching and assessing these required communication courses for programs requiring them in the College of Engineering, which does not include the chemical engineering program. The TC Program also offers a Technical Communication Certificate (TCC), which is of interest as an option for students in the chemical engineering program. This is an elective course of study open to all engineering students, which further enhances their communication abilities, particularly in editing technical documents (EPD 497); writing in teams, managing team projects, and developing leadership skills (EPD 265); discussing social, global, and ethical ramifications of technology (EPD 690); and designing documents for different audiences (EPD 395). The Technical Communication Internship capstone (EPD 398) gives students real world experiences with engineering communication projects in industry and government.

During assessment and preparation for the last ABET visit in 2006, the TC Program became aware of problems with skills transfer between the required technical communication courses and the senior design courses in the College of Engineering. In the interests of continuous improvement, one key goal the Program has had for the past six years is to work toward stronger relationships with COE faculty; specifically, TC is working toward a more coordinated approach to communication pedagogy across the curriculum.

In 2007-2008 the Director of the TC Program worked closely with senior design faculty in Mechanical and Civil Engineering to determine needs for those capstone classes; based on that experience and using information gathered from the Technical Communication Industrial Advisory Board, the TC Program developed a College-wide survey of faculty needs in Spring 2009 which identified specific communication concerns. With the feedback gathered from that faculty survey, TC proposed and received financial support from an Engineering Beyond Boundaries grant to begin creating some online communication modules to help supplement senior design courses. That Technical Communication Online Modules project has been supported for every year since 2009 by EBB grants. Work continues on the modules. The very act of creating and using those modules has led to quality improvement in the TC program and improvements in the teaching of communication college-wide.

The Technical Communication Modules that are now available are listed below; those currently being developed and pilot tested are in italics. The modules provide faculty with online quizzes and rubrics that can be used to supplement assessment of ABET student outcomes (d), (f), (g), and (i). TC is currently working toward new modules that will provide more support for teaching and assessment of student outcomes (h) and (j).

- Macro-Organization: Logic and Structure of a Lengthy Technical Report
- Micro-Organization: Unifying Paragraphs; Creating Transitions
- Writing Introductions to Technical Reports
- Arguments and Persuasion in Proposal Problem Statements
- Integrating Graphics into Documents
- Using Equations in Documents
- Conducting Credible Research and Evaluating Sources
- Using Sources and Avoiding Plagiarism
- Presentation Basics
- Writing Executive Summaries
- Writing in Teams
- Applying Engineering Ethics in International Contexts
- Designing Graphics

In the process of creating these modules, the Technical Communication Program developed performance criteria for the module rubrics that have been helpful in the ABET assessment process. In several instances, senior design faculty across the college have adopted or adapted the performance criteria used by the TC Program. The ABET process has thus motivated critical conversations between the Technical Communication instructors and college faculty about best practices in communication, teamwork, ethics, and lifelong learning.

5. Non-academic Support Units

The College of Engineering houses **nine** non-degree granting units that support the academic mission of the college. Individuals responsible for each unit are listed below, followed by sections that provide brief descriptions of the mission and scope of each unit.

College of Engineering Shop (design lab and instrument facilities in Engineering Centers Building): Shop Director, Larry Wheeler

Computer-Aided Engineering, Director Rob Kohlhepp

Diversity Affairs Office, Manuela Romero, Assistant Dean of Academic Affairs

Engineering Career Services, John Archambault, Assistant Dean, Student Development

Engineering General Resources, Manuela Romero, Assistant Dean of Academic Affairs

Engineering Media Services, director, Jeff Stevens

International Studies and Programs, director, Amanda Hammatt

Student Leadership Center, director, Alicia Jackson

Wendt Engineering Library and Wendt Commons, director, Deb Helman

6. Credit Unit

The UW-Madison adheres to the EAC Definition of a credit unit. Specifically, the Madison campus operates on a semester basis with a semester consisting of 15 weeks of classroom instruction followed by a summary week. It also has a great variety of sessions in the summer; sessions are from one to twelve weeks in duration. The general session is 8 weeks with final examinations being written in the last class period. The CBE 424 – Operations and Process Laboratory (Summer Lab) operates in special sessions of 5 weeks duration.

Lecture courses grant one credit for one 50-minute period of classroom instruction per week. Thus in a 15-week semester, 15 periods of classroom instruction yield one credit, and 45 periods yield three credits. Some three-credit courses meet only twice a week for 75-minute periods. In summer sessions, the meetings are more frequent and/or longer to meet or exceed the 15 period-per-credit standard.

7. Tables

Table D-1. Program Enrollment and Degree Data

Chemical Engineering Program

Fall Term	F/P	Enrollment Year				Total UG	Total Grad	Degrees Conferred (Academic Year)			
		1st	2nd	3rd	4th			BS	MS	PhD	Other
2011-12	F	0	12	62	180	254	127	22	2	5	0
	P	0	0	1	29	30	2				
2010-11	F	0	4	78	172	254	131	92	2	21	0
	P	0	0	6	22	28	1				
2009-10	F	0	11	80	128	219	119	49	4	16	0
	P	0	0	6	30	36	3				
2008-09	F	0	19	74	113	206	112	62	4	18	0
	P	0	0	5	23	28	3				
2007-08	F	0	16	55	85	156	120	50	5	21	0
	P	0	1	5	29	35	1				
2006-07	F	0	10	52	121	183	115	73	9	16	0
	P	0	1	7	20	28	2				

Official fall term enrollment figures (head count) for the current and preceding four academic years and undergraduate and graduate degrees conferred during each of those years. The "current" year means the academic year preceding the fall visit. Graduation statistics for “current” year include December graduates but not May or August graduates.

FT--full time

PT--part time

Table D-2. Personnel

Chemical Engineering Program

Year[1]: __2011_

	HEAD COUNT		FTE[2]
	FT	PT	
Administrative[3]	2		2
Faculty (tenure-track)	19		19
Other Faculty (excluding student Assistants)	2		2
Student Teaching Assistants	27		7.5
Student Research Assistants	131		81.2
Technicians/Specialists	1		1
Office/Clerical Employees	3		3
Others[4] (Academic Staff specialists)	2		2

Report data for the program being evaluated.

1 Data on this table should be for the fall term immediately preceding the visit. Updated tables for the fall term when the ABET team is visiting are to be prepared and presented to the team when they arrive.

2 For student teaching assistants, 1 FTE equals 20 hours per week of work (or service). For undergraduate and graduate students, 1 FTE equals 15 semester credit-hours (or 24 quarter credit-hours) per term of institutional course work, meaning all courses — science, humanities and social sciences, etc. For faculty members, 1 FTE equals what your institution defines as a full-time load.

3 Persons holding joint administrative/faculty positions or other combined assignments should be allocated to each category according to the fraction of the appointment assigned to that category.

4 Specify any other category considered appropriate, or leave blank.

Signature Attesting to Compliance

By signing below, I attest to the following:

That the Department of Chemical and Biological Engineering has conducted an honest assessment of compliance and has provided a complete and accurate disclosure of timely information regarding compliance with ABET's *Criteria for Accrediting Engineering Programs* to include the General Criteria and any applicable Program Criteria, and the ABET *Accreditation Policy and Procedure Manual.*

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Dean's Name (as indicated on the RFE)

________________________________ ________________________

Signature