Unit Plan for Assessing and Improving Student Learning in Degree Programs

Unit: Chemical and Biomolecular Enginering
Unit Head approval: Edmund Seebauer **Date: May 14, 2008**

SECTION 1: PAST ASSESSMENT RESULTS

Record of Continuous Improvement 2002-2007 – Closing the Loop

In our ABET Self Study report, we documented a number of significant changes to our overall educational program as well as individual courses based on our assessments of our program. We will here go through each item and address which assessments motivated the change. In some cases, it will be clear whether Objectives or Outcomes were the primary source of the change. In other case however, you will see that we received a strong message both from present undergraduates (outcome assessments) and from our broader constituencies (objective assessments – BS alumni, recruiters, senior industrial management, national educational leaders), yielding a consensus on the merits of a given change. Examples will be cited below.

Changes to our program are discussed in two places in our Self Study report: first, briefly in Section A Background Information on pp 2-3 and then in greater detail on pp 63-77 of Section B. In the brief summary on pp 2-3, it was not deemed appropriate to give detailed explanations as these came later on pp 63-77. Thus, for items where both objective and outcome assessments contributed to a change, the item might be listed under Category 2 or Category 3 – we didn't list in both. This becomes much clearer in the specific changes discussed below.

From page 64:
"The hiring of a Lecturer - Dr. Marina Miletic." This is a good example of a change arising from assessments of both Outcomes and Objectives. Our undergraduates on the 2003 Alumni survey and the 2001, 2002, and 2003 Senior Surveys reported a strong desire for improvements in the unit operations and senior design courses. They had also given positive feedback on the prior improvements in communications training in these courses and further efforts were warranted. Our BS graduates in the 2003 Alumni survey mentioned the strong desire for more hands-on practical training and better communication skills in over 30% of written responses. They specifically requested more practical training in design and operations. Thus it is impossible to lay this change in just one category, it truly addressed a consensus of feedback. **This change was motivated first by our Primary Objective as the changes in these courses provide many improvements in the students' abilities which will ultimately help them to achieve success as leaders in the field. Specific intermediate objectives and outcomes which also motivated the change are in categories (b), (c), (d), (f), (g), (k).**

Closing the loop:
Examining Senior Surveys from years 2004, 2005, 2006, and 2007, Unit Operations and Design are mentioned frequently. Students by and large have very positive feedback that these courses have improved and become more rigorous. On Senior Surveys from 2002 and 2003 (before she was hired), these courses are described as "a joke" and "weak." Students mention that these courses taught them much about system design, Aspen, troubleshooting, and experimental design. The 2007 Alumni survey also gave much feedback regarding Design where a number of respondents stated that compared to students in other schools, they felt they learned more and had higher expectations placed on them. Marina's teaching is specifically mentioned in the 2004-2007 Senior Surveys and the 2007 Alumni survey and comments are always positive. The most prevalent comment about her teaching is that the courses are so rigorous, that both Unit Operations and Design need to be two semesters each.

"The Department changed its name to Chemical and Biomolecular Engineering"
This change was primarily attributable to assessment of Objectives. It represented a response to an emerging national consensus and feedback from industrial leaders. Note that the Department was in the vanguard in the formation of this national consensus through the efforts of our former Head, Professor Charles Zukoski and our BS alumnus Steven Miller, CEO, Shell Oil Company in organizing the first Woodlands Conference on this topic. **This change is attributable to our Primary Objective.**

Closing the loop:
This change is so significant, it cannot be assessed using a Senior Survey or even a 5-year Alumni survey. A change of this magnitude requires assessment over a longer time period with multiple meetings of the Alumni Advisory Committee and Faculty.

"The Department established the Subcommittee on Biomolecular Engineering." We instituted a new Concentration in Biomolecular Engineering based on the work of this committee. This change was primarily motivated by assessment of Program Objectives and follows from the same feedback which motivated the name change. The goal is to provide leadership in developing new curricula in biomolecular engineering. Outcomes assessments played a role as well however, as we received feedback from undergraduates from Senior Surveys in 2004 and 2005 that they were very interested in the recognition offered by the Concentration in Biomolecular Engineering. The undergraduates requested frequent updates on the progress of this Concentration within feedback forums (See 2005 Student Survey) as its approval worked its way up through the campus administration. **The most important motivation for this change arose from our Primary Objective. Given the emerging importance of biomolecular engineering in a large number of critical areas of national interest (renewable energy/biofuels, public health crises/pharmaceuticals, product safety and public health consequences of food production, biosynthesis of industrial chemicals, drug delivery systems, etc),**

we recognized that to educate the leaders in the profession, we need to be leaders in education in the area of Biomolecular Engineering.

Closing the loop:
The documentation which follows our process of degree proposal, degree modification, faculty voting, and "Option in Biomolecular Engineering" proposal is provided in Appendix F. The result of this subcommittee was the creation of a Concentration in Chemical Engineering, of which 6 students are presently declaring.

From page 65:
"The building of a Microelectronics Processing Laboratory." Again, consensus input from assessments of both outcomes and objectives, with outcomes playing the dominant role here. Our students taking the CHBE 457 Microelectronics lecture course noted a desire for more hands on knowledge in this area. Our industrial partners expressed a desire for students to acquire a greater familiarity with the equipment in this area prior to their graduation. On the other hand, BS alumni from the 2003 survey also suggested the desire for this lab based on the new challenges they faced in their first few years of employment; hence assessment of objectives also play a supporting role. **As noted, Outcomes played the dominant role here with outcomes in categories (b), (c), (e), (k) of primary importance.**

Closing the loop:
The lecture and lab form part of an informal "concentration" in microelectronic processing. Both are unique enough (especially the lab) that they are featured on Intel's best practices higher education web site
http://www.intel.com/education/highered/Microelectronics/MicroFab.htm

The course has had Materials Science and Engineering, Chemistry, and students from other disciplines. The interdisciplinary nature of the course provides a benefit for students (helping fulfill Objective (d)), and permits them to delve deeper into microelectronic processing, leveraging Electrical and Computer Engineering courses. The students have stated on ICES evaluations that they enjoy the lab because it's much more open ended than most courses. The students deal directly with vendors and shops, and the weekly discussion meetings feature oral student presentations with Q & A.

"The completion of a Statistics course was made a mandatory requirement". As noted the major stimulus here was from assessment of objectives – the alumni surveys from 2003 as well as 2007 and employer feedback were the primary motivations here. Statistics is mentioned more than any other single issue in the 2003 five-year Alumni survey. Alumni did not mention the need for statistics in the Senior Surveys, but it was quite clear that it was invaluable after graduation. Therefore, **the Primary Objective was the principal motivation here as the feedback was consistent that a strong background in Statistics was essential for long term success in ones career.**

Closing the loop:
We have not had enough students take a Statistics course to see remarks on the 2001 – 2007 Alumni survey, however the Unit Operations instructor has noticed that report and presentations scores for statistics-intensive experiments such as Polymer Extrusion has gone up significantly since students have been taking STAT 400 or IE 300. Students felt far more comfortable using Minitab in this course since this requirement was instated.

" The need for improved skills in Linear Algebra was responded to by upgrading math requirement to MATH 415 Linear Algebra." This was primary a result of outcomes assessment as described on p 65. The instructor of the Process Controls course compiled quantitative data on students' performance on homework, quizzes, and labs. Results of these data showed that students were generally weak in linear algebra and this was hindering their learning of control systems. These data were consistently tracked for several semesters before the faculty made this decision. **Outcomes assessment in categories (a), (b), (c) and (e) were the primary motivation.**

Closing the loop:
Students' performance in Process Controls has improved as a result of this requirement. This is seen in their Fall 2007 final exam performance, in which they had a ~65% average although the problems heavily involved linear algebra (more than in previous years). The students who had low scores had taken the 2-hour linear algebra course by accident. Students with a stronger Linear Algebra background has helped in teaching process controls. Fewer "math" lectures in this course are now needed. Now the instructors can spend more time on controls fundamentals.

"The Advising and Career Services Office was expanded." Primarily motivated by outcomes assessments based on undergraduate feedback at all levels on advising and by graduating seniors on placement services. We based this mostly on feedback from Senior Surveys from 2001 through 2007. We collected quantitative data from graduates on their Advising and Career Services experiences. For all years on these surveys students stated that these services were good, but could use some improvement (such as more advising and career staff and more open walk-in hours – see 2005 Student Survey.) We have responded to these suggestions by first expanding the office with greater staff, then splitting the office in 2007 into two separate services. **The Advising and Careers Service Office handles a wide range of advice on course selection, career possibilities and sources of additional information for individual skills areas. This change was motivated by a broad range of feedback mostly from Seniors and cannot be attributed to any small subset of outcomes. The mandate to provide improved services in this area came as a definite consensus opinion from our graduating seniors.**

Closing the loop:

We will be closely monitoring the 2008 Senior Survey to see if students give the Advising and Career Services Offices high ratings for service and quality. Fall 2007 was when the split initially occurred, so we will compile 1-2 years of feedback before assessing the success of this reorganization.

"Dr. George McConaghy was introduced as a guest lecturer in Unit Operations and Senior Design." Primarily motivated by outcomes assessment. Students reported a desire for more feedback from the "real world" and a better knowledge of what is expected in industry. This was addressed multiple times in the 2003 Alumni survey where students stated that a more practical experience-based preparation for the "working world" was necessary. This is also a suggestion that is brought up for Senior Design and Unit Operations course in Senior Surveys for 2001-2003. **Outcomes in categories (c), (d), (e), (f), (g), (h), (i), (j) (k) motivated this change.**

Closing the loop:
Every single lecture which Dr. George McConaghy gives in the Unit Operations and Senior Design courses is qualitatively and quantitatively evaluated by students in the following lecture. Dr. George McConaghy consistently receives a score greater than 7 out of 10 for all of his lectures. Students find that his lectures are informative and provide a unique perspective on engineering.

"The computer lab is undergoing continuous replacement of computers." Primarily motivated by outcomes assessment based on student feedback. The computer lab has been brought up on Senior Surveys 2001-2007. Students have also completed separate Computer Surveys for the department where they have stated that not only do almost all of them use the computer lab between 3-10 hours a week, but the computer lab is also the single most important area for improvement for their educational experience. **Computers play an important role in every category (a)-(k) hence outcomes in all categories play a role in this change.**

Closing the loop:
Faculty and IT administrators have observed that over the past year, at any given time, the new computers in the laboratory are almost always in use. We are working now toward remodeling the space, replacing servers, and upgrading printers before 2009.

From p66
"The addition of the Banner online course registration and management system."
Primarily motivated by outcome assessments based on student feedback and need for efficient university administration. **Similar to the above, the campus registration and management system plays a role in so many aspects of a student's academic life that it is impossible to assign to a given category (a)-(k). It is certain that a campus administrative computer system which does not function effectively has a negative effect on all outcomes.**

"Engineering 100 was added as a course requirement" Primarily motivated by outcomes assessment based on student feedback. Students in all Senior Surveys 2002-2007 have stated that their placement in the College of Liberal Arts and Sciences is a disadvantage. This change was also triggered by multiple students going to see Dean Susan Larson in the College of Engineering to tell her that students in Chemical Engineering, because of the department's location as well as its placement in the College of Liberal Arts and Sciences, do not feel like engineers nor a part of the College of Engineering. After many years of collecting this feedback, Dean Larson spoke to the faculty about this important issue. Furthermore, the instructor for the Spring course Introduction to Chemical Engineering course (What do Chemical Engineers do?) collected mid-term feedback over many years which stated that students needed advising and resume guidance in the Fall of the Freshman year, not the Spring. Advising and career planning is necessary immediately when students enter in the Fall and this course provides this assistance. **Primarily motivated by outcomes in categories (e), (f), (h), (i), (j).**

Closing the loop:

The first year of students to take Engineering 100 will be Sophomores next year. So far, it is too early to tell what impact this course will have on them overall, but we are hearing good feedback so far. Most helpful is that this course usually helps students stay within the major. They are introduced to their department early on and are made welcome from the beginning. They are also introduced to services and individuals who can help them with any challenge they face (e.g. academic integrity, time management) or interest they would like to pursue (e.g. study abroad, co-oping.)

SECTION 2: REVISED ASSESSMENT PLAN

(a) PROCESS:

Process Used to Establish Program Educational Objectives

The current Program Educational Objectives are an outcome of many years of program improvement and planning. The current set of objectives is derived from exhaustive discussions with the constituent groups and are consistent with the educational components of the Department Mission Statement.

In 1997 the UIUC Provost charged each campus unit with developing and implementing a plan for assessing training outcomes for their undergraduate and graduate majors by March 30, 1999. Each plan needed to be approved by the Provost and was an important component of the North Central Association of Colleges and Schools accreditation review carried out in September 1999.

The plan was developed after discussions with the faculty, staff, members of the Departmental External Advisory Committee, students of the department, the Executive Boards of the AIChE (American Institute of Chemical Engineers) Student Chapter and the NOBCChE (National Organization of Black Chemists and Chemical Engineers), alumni, as well as present and prospective employers. The Criteria 2000 Committee (C2K), consisting of a representative from each engineering department, organized by the College of Engineering has played an instrumental role in coordinating the departmental efforts and gathering data common to all College of Engineering programs. As suggested by ABET, two interconnecting loops provide basis for the plan. The ABET-suggested double loop was modified to embrace our own unique process of assessment, improvement, and modification. The Objectives Loop is shown below and the Outcomes Loop is shown in the next section.

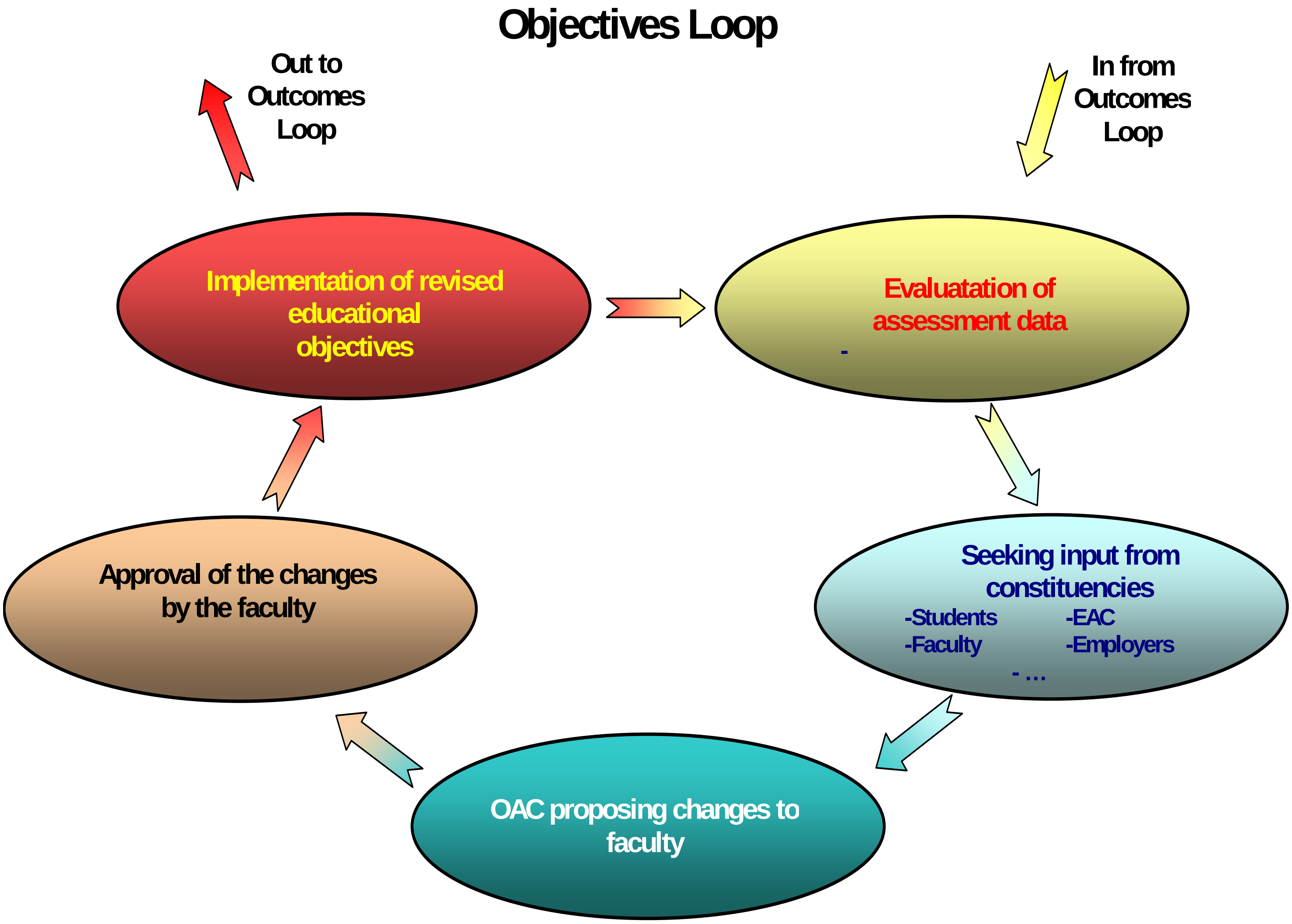

Figure 1: Objectives loop used for program/curriculum assessment and evaluation. OAC = Outcomes Assessment Committee, EAC = External Advisory Committee

Developing the Plan

The Outcomes Assessment Committee (OAC) is a committee within the department headed by Professor Jon Higdon. As can be seen from the Objectives loop above, the Outcomes Assessment Committee is critical in reviewing assessment data from different direct and indirect sources. The direct sources of assessment data include course outcomes evaluation (scoring on specific questions on tests, quizzes, and homework), and standardized test assessment. The indirect sources of assessment include ICES Reports (end of semester evaluations), Chancellor's and Departmental Senior Surveys, hiring statistics, feedback from the External Advisory Committee, and Campus, College and Departmental alumni surveys. Upon review of this data, the committee suggests changes to the faculty which affect the shift in emphasis of the curriculum and its objectives to reflect appropriate adjustments based on the feedback. Also, OAC members solicit input and feedback from the entire faculty both by personal contact and via department faculty meetings. The committee guides the development of assessment tools, evaluates data, and proposes changes in program in response to this evaluation, but the whole faculty participate in the development of the evaluation process.

For each required course, information has been compiled to document the objectives, outcomes, and assessment tools used in that course. These forms for each course provide the information about the course objectives, compares it with the ABET criteria and program objectives and explains the method of assessment. This information is provided in Appendix I-B.

In developing our plan, input from **industrial representatives** was highly valued. The process of discussing our program objectives and the outcomes of our program with industrial representatives is a key element of our continued assessment plan.

Direct assessment of program and course objectives and outcomes is performed through evaluation of students' **course homework, quizzes, exams, projects, and presentations. Indirect input from students is garnered through chemical engineering student leaders from active student societies in the Department: American Institute of Chemical Engineers (AIChE), and Omega Chi Epsilon (OXE). Using a survey format, these student leaders solicit input from a broad cross-section of our students concerning our programs' objectives, outcomes, assessment tools and results, as well as other issues relevant to students' educational experience. The faculty review this data once a year during a faculty meeting. In addition to this more formal mechanism, the faculty, staff, and administration of the Department receive continual input from our students through our daily contact with them. The combination of the reports from the Outcomes Assessment Committee and student surveys have led to improvement of the program, grading policies, and facilities. Documentation of major programmatic changes requires**

campus approval and the necessary steps are taken to ensure that this approval is given.

Faculty **input is obtained formally through the Outcomes Assessment Committee, which meets approximately two times during the academic year. A wide array of issues, including those directly related to our undergraduate programs' objectives, outcomes, assessment, and continuous improvement, are presented and discussed at these meetings.**

The ChBE External Advisory Committee **is composed of 8 elected members, who are successful, experienced individuals in their careers. Alumni of the Department, active and former faculty members, and others in close association with the Department are eligible for membership on the Committee. Most of the members are from industry, although a few are from government labs or academia. The Committee's purpose is to help the Department achieve its mission and successfully achieve its program objectives. The Committee does not meet on a regular basis but meetings are held whenever the Department Head needs advice. The focus of these meetings usually centers on undergraduate and graduate program issues.**

Input is obtained from employers **both through External Advisory members, many of whom employ our graduates, through meetings with recruiters and through continual canvassing of corporations during visits by the Head and Assistant Head to corporate locations employing our students. The Department Head, Director of Corporate Relations, Head Academic Advisor, and Department Lecturer receive feedback from employers on a regular basis and periodically meet with company recruiting teams on campus. In order to heighten their visibility with students, employers are becoming increasingly active in funding scholarships and student society projects, speaking at student society meetings and courses such as ChBE 121 (The freshman course described earlier), and ChBE 431 (Capstone Senior Design.) In all instances, these employers are quick to comment on the strengths and make suggestions for improvement of our undergraduate programs. We value these comments and suggestions highly and use them in the assessment and improvement of our programs.**

Relationship Between Program Educational Objectives and Program Curriculum

The curriculum is the ultimate process by which the faculty members guide and assist students in developing the knowledge, skills, and attributes necessary for a B.S. graduate in Chemical engineering. To illustrate this direct relationship, the Program Educational Objectives have been mapped into the Chemical engineering curriculum on a course-by-course basis.

Achievement of the Program Educational Objectives requires integrating our overall learning objectives throughout the entire curriculum. As a result, the Program Educational Objectives have been translated into specific learning objectives for each Chemical engineering course. These learning objectives are used to help identify and implement the outcomes required to satisfy the overall program objectives. These objectives also ensure that course material will consistently address the learning objectives that are necessary to achieve the Program Educational Objectives regardless of who teaches the class or which text and/or teaching method is used. The objectives and outcomes for each course in the ChBE program, both required and elective, have been defined and related to the program objectives and outcomes, please see Appendix I-B.

Faculty assume the responsibility for the development of educational objectives relevant to the courses they teach. The students are made aware of the learning objectives in each course. These objectives are a direct reflection and are based on the curriculum objectives. Faculty teaching is included as an item for discussion in each faculty member' s annual review. Faculty members must quantitatively and qualitatively describe their teaching and improvements made. Each faculty member's teaching performance is used as a criteria for promotion and tenure.

While the data from an array of assessment tools discussed below demonstrate that our graduates do indeed meet the ChBE program outcomes, and, therefore, objectives, improvements to the curriculum are always made. As discussed below, several enhancements to the curriculum that have been suggested by this assessment/continuous improvement process have been completed, and others are currently in various stages of discussion and implementation.

Review Cycle

Educational objectives are reviewed and revised on a regular basis. The next review will occur almost immediately after the upcoming ABET accreditation visit, *i.e.*, in the 2007-2008 academic year, using the results and recommendations garnered from the visit, various student and alumni surveys, and the EAC final report as input. In each case, the review and revision process will carefully consider suggestions from the constituent groups, as was done in the current cycle.

The Outcomes Assessment Committee (OAC) meets once a semester to review course and program outcomes and objectives. In many cases objectives and outcomes are reviewed and acted upon by faculty who regularly teach certain courses. Direct data such as unacceptable performance on tests, quizzes, and homework indicate the need to revise

outcomes and teaching approaches to better satisfy course objectives. This review process is often performed and evaluated during and between semesters. Within the Unit Operations and Senior Design courses, data is collected during the semester to identify areas of learning weakness and is directly acted upon before the end of the semester. The instructor also surveys students in the course at least once a semester to determine what aspects of the course students would like to keep the same or change. This is valuable because every group of students is different and display different learning styles and technical backgrounds. The processes for review of objectives and for outcomes evaluation are superimposed, since objectives and outcomes are directly linked. The review process is described in more detail in Section 3 of this self-study.

(b) <u>STUDENT OUTCOMES</u>: List Unit's student learning outcomes (knowledge, skills, and attitudes).

The mission of the Department of Chemical Engineering is to provide a broad-based education in Chemical engineering and related fields for highly qualified undergraduates; to accomplish, in conjunction with a program of graduate education, research recognized by peers as among the most significant in the world; and to serve society through Chemical engineering leadership in matters of national policy, education, professionalism, and economic development.

To accomplish this mission we have designed our undergraduate educational program with the goal of educating leaders who will **have a deep understanding of engineering fundamentals** and **are able to apply this knowledge to management of complex systems with particular attention to the Chemical process and product industries.** We believe that our students will be best served by our program providing them a foundation on which to build careers through life-long learning and teaching students how to learn. This foundation is thus based on the key concepts of engineering while providing the students with the training to be able to rapidly apply their knowledge to solving problems and developing relevant solutions.

Formalizing our educational objectives to be consistent with Engineering Criteria 2000 (EC2000) of the Accreditation Board for Engineering and Technology (ABET) has been performed through a process described below involving consultation with stake-holders in our program. Our objectives have been developed to ensure that we comply with all accreditation agencies (ABET and NCA) requirements. Our set of educational objectives satisfies the mission of the University, the College of Engineering and the Department. These objectives are thus designed to be consistent with the outcomes mandated by ABET. We emphasize that the convergence of the mandated Criteria 3 outcomes and our educational objectives is a result of extensive discussions where we realized that we were generally making only minor wording changes to the ABET outcomes. In the end, we embraced the ABET (a) through (k) list of objectives as our own program objectives. We have further expanded on these program objectives by specifically outlining expected program outcomes for each objective. The outcomes are outlined below each objective.

The Program Educational Objectives are based on the concept that the educational experience in our Department should integrate the knowledge and skills acquired in a rigorous set of courses to enable the graduates of the program to:

(a) Apply knowledge of mathematics, science, and engineering

1. Graduates must demonstrate the ability to apply fundamental concepts gained from Mathematics, Physics, and Chemistry courses to all Chemical Engineering courses.
2. Graduates must also apply and successfully integrate previously learned fundamental concepts of Chemical Engineering, Mathematics, and Science courses to all subsequent courses, technical electives, and capstone courses such as Unit Operations and Senior Design.

(b) Design and conduct experiments, as well as to analyze and interpret data

1. Graduates must demonstrate the ability to analyze engineering data to interpret trends, develop models, and evaluate their relevance.
2. Graduates must also successfully identify the need for experiments, develop an experimental design, and analyze the data quantitatively.

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

1. Graduates, when given objectives and constraints, must successfully design a chemical system, process, product, or set of experiments to achieve a specific economic, safety, and production goal.
2. Graduates must have the ability to design systems that are functional, safe, efficient, and ethically sound.
3. Graduates must be able to identify the limitations of any design. Graduates must demonstrate the ability to evaluate and determine whether a design is adequate and should be implemented.

(d) Function on multi-disciplinary teams

1. Graduates must display proficiency in working in teams. Students must display the ability to divide work equitably, set individual and team goals, and complete work in a timely fashion.
2. Graduates must be able to give and receive constructive criticism, listen and incorporate others' ideas, neither dominate nor lack assertiveness within the team, and take initiative.
3. Graduates must be able to identify their own strengths and weaknesses and optimize the team structure to take advantage of everyone's strengths.

(e) Identify, formulate, and solve engineering problems

1. Graduates, when presented any engineering problem, must be able to identify all relevant information given, identify what information must still be found, construct a diagram to visually set up the problem (when appropriate), establish a plan for solving the problem, solve the problem using previously learned

knowledge or new knowledge learned “just in time”, and evaluate the solution for validity and relevance.

(f) Understand professional and ethical responsibility

1. Graduates must know and identify the key tenets of the AIChE Code of Ethics and how they apply to their professional work.
2. Graduates must be able to identify all stakeholders and their perspective in an ethical dilemma.
3. Graduates must be able to identify what to do when they are presented with an ethical dilemma.
4. They must understand the difference between professional responsibilities and ethical responsibilities.

(g) Communicate effectively

1. Graduates must demonstrate the ability to successfully describe engineering projects or problems in both written and oral form to a variety of audiences: management, fellow engineers, and lay persons.
2. Graduates must be able to effectively present data, persuade audiences, and clearly and concisely answer questions.

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

1. Graduates must have a strong understanding of the impact of their work. Graduates must be able to recognize the implications of any project on all persons involved: management, fellow engineers, all other workers, local communities, and people affected on the state/national/global level.
2. Students must translate this understanding to their design and decision making process.

(i) Recognize the need for, and be able to engage in life-long learning

1. Graduates must have automated the learning process to the degree that self-learning and “just in time” learning are a natural part of solving any engineering problem.
2. Graduates must demonstrate the ability to solve complex problems using a combination of their fundamental engineering principles and self-taught knowledge through research of the subject. Therefore, graduates should feel confident in solving any problem (technical or non-technical.)

(j) Have a knowledge of contemporary issues

1. Graduates must be able to identify relevant issues affecting engineers today and in the future.

2. Graduates must identify their professional role in these issues.

   (k) Use the techniques, skills, and modern engineering tools necessary for engineering practice.

1. Graduates must be proficient in use of engineering equations, tables, charts, published data, and simulation software such as Polymath, Matlab, and Aspen to solve engineering problems.
2. Graduates must display an understanding of the appropriateness of all of these tools, i.e. identify which tool should be used when and the limitations of each tool.

Our educational program is designed to serve the needs and aspirations of a broad set of stake holders (constituencies) including students and their families, faculty, companies who hire our graduates, graduate schools, corporate sponsors, the State of Illinois, the Nation, and ultimately, the world population. To inform our constituents we have posted our Mission Statement and Program Objectives on the departmental website (http://www.ChBEmeng.uiuc.edu) as well as the College of Engineering Programs of Study catalog.

Implementation of these educational objectives and changes to them are made as the result of consultation with these stakeholders. Faculty in the Department have a long tradition of extensive discussions on matters of educational policy amongst ourselves, with students, and with our corporate constituencies. The program has been dramatically altered in response to the input we have received from these groups. These conversations and continual dialogue with our students and among the faculty (at regularly scheduled faculty meetings) have identified the following pressures that are acting on the profession of Chemical engineering:

- An accelerated drive towards knowledge based economy that is placing a premium on skills such as communication, teamwork, life-long and distance learning.
- A greater demand for minority and underrepresented graduates to fill positions in industry.
- Globalization of the economy that increases the need for students to know how to work within and across different cultures, especially in teams.
- A growing diversity in workplace and classroom increasing the needs of the Department to be active in attracting and retaining minority and women students.

- A shift in the Chemical and Petroleum industries which is resulting in a increased demand for Chemical Engineers trained in technologies related to bio processing and alternative fuels.
- The emphasis for a balance of fundamental skills (distillation, heat and mass transfer) and specialized skills (microelectronics, biology, food science).
- Expansion of the need for Chemical engineers in the electronics, pharmaceutical, food, personal care and agricultural industries.

(c) <u>MEASURES AND METHODS USED TO MEASURE OUTCOMES:</u>

Documentation of Level of Achievement of Objectives

Program Educational Objectives present a means of systematically focusing both the feedback that we obtain and our efforts in response to the feedback. Our current educational objectives are directly modified through evaluations of student tests (course and standardized), quizzes, homework, projects, and presentations. Every instructor tracks performance for educational objectives and modifies the course to include lectures, homework, or projects that help students develop greater strength for a particular weakness. Most of these course modifications are performed immediately when the problem is noticed. Long term proactive solutions are implemented for future classes if the instructor sees that the problem is pervasive and deems it necessary. All of this is documented on a course-by-course basis and is described in the course syllabi section in the Appendix I-B.

Our methods of assessment are documented. We use direct and indirect methods of assessment to effectively track student performance while they are in our curriculum and after they graduate. The following assessment methods are documented:

- Quantitative results of report scores for Senior Design and Unit Operations classes, linked to course objectives, course outcomes, program objectives, and program outcomes.
- Peer-on-peer and instructor-student quantitative and qualitative observation of performance in Senior Design and Unit Operations courses. This is direct assessment of student performance on team projects.
- **The Fundamentals of Engineering (FE) exam is a direct assessment method that assesses student preparedness for the workplace by testing fundamental engineering understanding.**
- **The Graduate Record Exam (GRE) is a direct assessment method that assesses student preparedness for graduate school by testing fundamental math, writing, and reading.**
- **Midterm Course Feedback is an indirect assessment method where students assess the quality of Unit Operations, Senior Design, and Introduction to Chemical Engineering courses halfway through the course.**
- **Surveys of graduating seniors are an indirect method of assessment and allow graduates to assess faculty, resources, courses, equipment, advising, and (a)-(k) confidence. These surveys are in two forms:**
  Chancellor's survey
  AIChE/Omega Chi Eplison Senior Surveys

- **Surveys of alumni are in indirect method of assessment and allow alumni to point out strong and weak points of their education, including (a)-(k) confidence. These surveys are usually every 5 years.**
- **Instructor/course evaluations are an indirect assessment method that students use to give instructors feedback regarding their level of learning and confidence in course material and the quality of teaching.**
- **Employment statistics are both a direct and an indirect assessment of our program as a whole.**

3. Program Outcomes and Assessment

The program objectives and outcomes were outlined Section 2. These objectives and outcomes are a direct reflection of Criteria 3 (a) – (k) requirements, as the program and ABET objectives are the same. Therefore there is one-to-one correlation between our program objectives and program outcomes.

The following table includes all of our program objectives (a)-(k) and program outcomes (numbered) with a description of how our curriculum ensures that program outcomes are achieved by our graduates:

Table 1: Program Outcomes and Objectives and their Application to our Chemical Engineering Curriculum

Program Objective/Outcome	**Relationship to Curriculum**
(a) Apply knowledge of mathematics, science, and engineering	
1. Graduates must demonstrate the ability to apply fundamental concepts gained from Mathematics, Physics, and Chemistry courses to all Chemical Engineering courses.	Students take: 2 Gen. Chemistry lecture courses, 2 Gen. Chemistry labs 2 Organic Chemistry lecture courses, 1 Organic Chemistry lab 2 Physical Chemistry courses 1 Analytical Chemistry course 1 Analytical Lab 5 Mathematics Courses: Calculus I, II, and III, Linear Algebra, and Differential Equations 3 Physics courses 1 Statistics Course 1 Computer Science Course All of these are usually taken within the first three years or sooner. This knowledge is applied to their nine fundamental Chemical Engineering courses, taken over the last three years.
2. Graduates must also apply and successfully integrate previously learned fundamental concepts of Chemical Engineering, Mathematics, and Science	Courses such as Process Control, Unit Operations, and Senior Design depend on a strong basis of prerequisite courses. These courses involve multi-component processes and the design, evaluation, and optimization of separation, reactor, heat transfer, and fluids units. These courses demand that students not only have a mastery of

courses to all subsequent courses, technical electives, and capstone courses such as Unit Operations and Senior Design.	fundamental mathematics and science, but also of all previous engineering courses. Unit Operations and Senior Design are specifically structured to require students to use knowledge from **all** other engineering courses.
(b) Design and conduct experiments, as well as to analyze and interpret data	
1. Graduates must demonstrate the ability to analyze engineering data to interpret trends, develop models, and evaluate their relevance. 2. Graduates must also successfully identify the need for experiments, develop an experimental design, and analyze the data quantitatively.	Students design their own experiments in Unit Operations (with no assistance from instructors) having been given a set of objectives or deliverables. Students must interpret data, develop trends and models where appropriate and comment on the validity of the results. Students are also required to take a Statistics course which prepares them for organizing data and evaluating significance of trends. These skills are used regularly in the Unit Operations course. Many students elect to do undergraduate research. This counts as a Chemical Engineering elective and students' work is centered around data collection, analysis, and publication in journals.
(c) Design a system, component, or process to meet desired needs within realistic constraints	
1. Graduates, when given objectives and constraints, must successfully design a chemical system, process, product, or set of experiments to achieve a specific economic, safety, and production goal. 2. Graduates must have the ability to design systems that are functional, safe, efficient, and ethically sound.	Students in the Freshmen course ChBE 121 must work in groups of four to develop a new, novel Chemical Product. The chemical product must be safe, functional, manufacturable, and solve an important problem. Students present their product idea in front of the class and instructors. Students must prove and defend their design in front of instructors and fellow students. Students in Unit Operations work in teams, are given a unique set of objectives and deliverables, and must design and evaluate experiments to achieve them. Students are graded on accuracy, safety, and maximizing production capacity and/or profit. Students in Design work in teams and are given a specific set of objectives for the design of a process plant by the end of the semester. This plant must meet specific economic, safety, efficiency, and production goals. The final design incorporates two previous non-optimized designs to produce a final optimized process.
3. Graduates must be able to identify the limitations of any design. Graduates must demonstrate the ability to evaluate and determine whether a design is adequate and should be implemented.	In Unit Operations, students work in groups of three and rotate use of experiments. During Rotation 1, preliminary experiments are performed to characterize the system. During Rotation 2, the new group must evaluate Rotation 1's report, findings, and data. They choose to either use their data or to not use it and run new experiments. In Design, students develop two preliminary designs

	before they develop their final. Each design involves more detail and optimization than the previous.
(d) Function on multi-disciplinary teams	
1. Graduates must display proficiency in working in teams. Students must display the ability to divide work equitably, set individual and team goals, and complete work in a timely fashion.	Students start working in teams as early as Freshman year where they work on an Engineering Open House (like an Engineering Science Fair for the University of Illinois) project and a Chemical Product Design project. They work in groups of 4-8. Students work in groups of three in Unit Operations in three Rotations of equipment. Their group work makes up the majority of their grade. Students work in groups of 4-5 in Senior Design oftentimes up to 40 hours per week. Their group work also makes up the majority of their grade. Because active cooperative learning is used in every single lecture for Unit Operations and Senior Design, students avidly practice discussing issues in teams with students in class. This helps all students practice team roles and develop proficiency in listening, writing, critiquing, and behaving professionally.
2. Graduates must be able to give and receive constructive criticism, listen and incorporate others' ideas, neither dominate nor lack assertiveness within the team, and take initiative.	Students are formally taught effective team work skills in Senior Design and the elements of successful and unsuccessful teams. Students must evaluate themselves and each other on listening skills, giving and receiving constructive criticism, incorporating others' ideas, being domineering or submissive, and taking responsibility for the success of the team. These peer evaluations make up approximately 12-15% of their final grade.
3. Graduates must be able to identify their own strengths and weaknesses and optimize the team structure to take advantage of everyone's strengths.	Students must individually evaluate their own strengths and weaknesses (by filling out a questionnaire) and discuss this with their Senior Design group. Based on these data, the group decides on a set of team rules and how work will be appropriated. This documentation is shared with the instructor and is valuable for keeping track of which students break group rules.
(e) Identify, formulate, and solve engineering problems	
1. Graduates, when presented any engineering problem, must be able to identify all relevant information given, identify what information must still be found, construct a diagram to visually set up the problem (when appropriate), establish a plan for solving the problem, solve	Students are taught this skill not only from their first Chemical Engineering course (ChBE 221 – Mass and Energy Balances), but also in their prerequisite courses such as Mathematics, Physics, and Chemistry. Students have diverse experiences with setting up and solving literally hundreds of problems by the time they graduate. Students also gain real world experience with solving engineering problems through their research, internship, and co-op experiences.

the problem using previously learned knowledge or new knowledge learned "just in time", and evaluate the solution for validity and relevance.	
(f) Understand professional and ethical responsibility	
1. Graduates must know and identify the key tenets of the AIChE Code of Ethics and how they apply to their professional work.	This is formally taught and discussed in Senior Design. Students spend 3-4 lectures identifying which ethics tenets are broken and upheld in different case studies which include chemical engineering-relevant issues. Students identify all tenets of the Code of Ethics.
2.Graduates must be able to identify all stakeholders and their perspective in an ethical dilemma.	As part of the work performed for these case studies, students have to look at a chemical engineering dilemma from the point of view of the chemical engineer, his boss, the boss's boss, the CEO of the company, the operators, the operator's supervisors, and workers in a third world country that must make the product.
3. Graduates must be able to identify what to do when they are presented with an ethical dilemma.	This is formally discussed in Senior Design and Unit Operations. In Senior Design, students are taught that in an ethical dilemma one must weigh many options and the consequences of those choices. Legal counsel is always advised. In Unit Operations, we discuss the nine worst Chemical Engineering Disasters of all time, why they occurred, and how they could have been prevented. Each student is responsible for one case study and for facilitating discussion in class.
4.They must understand the difference between professional responsibilities and ethical responsibilities.	The differences between these are both taught in Unit Operations and Senior Design. Students are taught of their professional obligations to their company, but that these must always be in alignment with ethical obligations to customers and the community.
(g) Communicate effectively	
1. Graduates must demonstrate the ability to successfully describe engineering projects or problems in both written and oral form to a variety of audiences: management, fellow engineers, and lay persons.	Students are required to take Rhetoric 105 or Composition I freshman year as a communication requirement. Students are also required to take 1 credit hour of Composition II in Unit Operations and another credit hour in Senior Design. In both courses, 25% of the grade for all assignments is allocated to readability and writing quality. For both courses, 40% of the students' presentation score is allocated to delivery and presentation style. Numerous effective writing and presentation lectures are given in Unit Operations and Senior Design. Every semester Dr. George McConaghy (retired BP Amoco engineer) delivers a lecture on effective reports and

	presentations in addition to the instructor's numerous lectures. Students give many presentations and write numerous reports in Chemical Engineering courses and their prerequisites and electives. Written reports are mandatory for: All Chemistry lab courses Unit Operations – Three lengthy reports and two Workplans, along with many small writing assignments. Senior Design – Five lengthy reports (two individual and three group reports) Oral reports are mandatory for: ChBE 121 – One formal 15 minute presentation Unit Operations – two formal 1 hour presentations Two informal 25 minute and 5 minute presentations Senior Design – 1 formal 1 ½ hour presentations 1 formal 30 minute presentation Also, many technical electives involve presentations. Please see syllabi. As was mentioned before, every lecture in Unit Operations and Senior Design features active cooperative learning where students break up into groups during class time and work on solving problems or brainstorming. Students develop professional and verbal communication skills every lecture and also have the opportunity to network with other students. Many students form study groups with the people they meet through their active learning groups.
2. Graduates must be able to effectively present data, persuade audiences, and clearly and concisely answer questions.	Students are given feedback by the professor, the TA, and by fellow students attending their presentations. Each of these audience members quantitatively evaluate the presenter on technical content, delivery, organization, and ability to accurately and succinctly answer questions. This is done for all Unit Operations and Senior Design presentations.
(h) Have broad education necessary to understand the impact of engineering solutions in a global, economic, and environmental societal context	
1. Graduates must have a strong understanding of the impact of their work. Graduates must be able to recognize the implications of any project on all persons involved: management, fellow engineers, all other workers, local communities, and people	This is taught both in Senior Design and Unit Operations courses. In Unit Operations, students learn the impact of poor engineering decisions and the consequences in terms of lives lost. They understand the role that engineers, workers, and management had in these situations and their contribution to the result. In Senior Design, students evaluate the impact of their plant on all relevant constituents. This includes both positive and negative impact. They carefully evaluate the

affected on the state/national/global level.	key processes that need to be in place to ensure the safety of the workers and the community. They also evaluate the environmental impact of their plant. Students also evaluate how they can make their process run on sustainable reactants or how they can replace their product with one that is made of renewable resources.
2. Students must translate this understanding to their design and decision making process.	The research they conduct above is reflected in their design and they are assessed on how safe and environmentally-friendly their design is.
(i) Recognize the need for, and be able to engage in life-long learning	
1. Graduates must have automated the learning process to the degree that self-learning and "just in time" learning are a natural part of solving any engineering problem. 2. Graduates must demonstrate the ability to solve complex problems using a combination of their fundamental engineering principles and self-taught knowledge through research of the subject. Therefore, graduates should feel confident in solving any problem (technical or non-technical.)	Students soon into our curriculum notice that engineering problems are not usually "plug-n-chug." They require thought, brainstorming, going to the library, working with others, speaking with professors and TAs, digging into other books, and sometimes looking on-line. Students frequently have to do research (on-line or in the library) for many of their Chemistry and Chemical Engineering courses. Many electives require a specialized project, which requires research into a particular problem. Students, through creative design projects throughout their curriculum, have had the opportunity to develop new ideas for a chemical product (such as through ChBE 121 and Senior Design.) Their ideas have been tested for validity by performing background research and learning more about how the product might work and how it can be optimized. In Senior Design students are required to write a series of Long-Term Professional, Financial, and Health Goals, identifying: What the Goal specifically is What the target completion date is What needs to be done to prepare What is the first step What has been accomplished so far (within a month) This goal setting exercise has taught students the value of clearly identifying what they want and then finding information on it. Students are obligated to take that first step – buy and read a book on the topic, take a class, or whatever it takes to get the project started.
(j) Have knowledge of contemporary issues	
1. Graduates must be able to identify relevant issues affecting engineers today and in the future.	Some of the challenges that students are exposed to in our curriculum (both inside and outside of the classroom) include the energy crisis, the need for clean water, the need for food for a growing population, the need for plastics in a time when oil is running out, and the need for a cleaner and more stable environment.

	Through the Introductory course (ChBE 121) students learn elements of Chemical Engineering and the emerging fields in Chemical Engineering. They reflect on whether they want to be a part of solving the growing challenges that face us today. In the Unit Operations course, students discover the serious obligations and responsibilities of engineers in a global marketplace driven by consumer demands and tight deadlines. They examine case studies as recent as the BP Texas City, TX incident that occurred in 2005 and will be examining the Formosa Plastics Illiopoilis, IL disaster that occurred on March 6, 2007. In the freshman ChBE 121 course, numerous presentations are given by working and retired engineers sharing their workplace experience with the students. These lectures are help students connect with the real world of Chemical Engineering. They discover the projects that typical engineers and co-ops work on. Guest lecturers have been from Lyondell, Kimberly Clark, BP Amoco, Shell and many others. We have also had lectures from small consulting companies such as Fauske and Associates. Dr. George McConaghy (retired BP Amoco Chemical Engineer) gives five lectures a semester on topics ranging from "My Life as a Chemical Engineer" to "The Specialized Plastics Industry" to "Product Design and Market Research"
2. Graduates must identify their professional role in these issues.	In the Senior Design course students examine Chemical Engineering-related case studies and must determine what they would do in the situation. Students discuss the situation in groups and present their decisions in front of the class. The class as a whole discusses the advantages and limitations of each issue.
(k) Use the techniques, skills, and modern engineering tools necessary for engineering practice.	
1. Graduates must be proficient in use of engineering equations, tables, charts, published data, and simulation software such as Polymath, Matlab, and Aspen to solve engineering problems.	Students begin using the CRC and Perry's Handbooks both online and in hard copy format almost from the first day in our curriculum. They are introduced to the key equations in Chemical Engineering in the freshman ChBE 121 Introductory course. They become familiar with psychrometric charts, steam tables, and other data in Mass and Energy Balances class (ChBE 221). Students become proficient in Matlab in Computer Science 101 as well as in Process Controls class. Students

	use Femlab for solving problems in ChBE 421 (Momentum and Heat Transfer). Students use Polymath and similar solvers such as Mathematica in the Reactor Design course as well as in Senior Design and Unit Operations. Students use Aspen approximately 20 hours per week in Senior Design. They are given formal training during the first few weeks of the course. Their final process flow diagram must be a converged Aspen-derived design.
2. Graduates must display an understanding of the appropriateness of all of these tools, i.e. identify which tool should be used when and the limitations of each tool.	Use of equations and tables are taught in numerous courses and their appropriate applications are discussed in individual classes and by working through specific examples. The limitations and proper use of Aspen in Senior Design is a topic that is discussed quite extensively. The choice of a Thermodynamic model, the meaning of convergence, the algorithm (and its limitations) which Aspen uses to solve mass and energy balances are all topics that are discussed in the course. Students are graded on their interpretations of results and their choice and justification of a thermodynamic model. Students in Unit Operations are required to develop predictive empirical and theoretically-based models for equipment characterization. Students are required to identify the validity of the model and to discuss its limitations. Students are evaluated on presentation of models and their application.

The table above represents a brief snapshot of how our courses support our program objectives and outcomes directly. To avoid being overly wordy, not all information on all courses were provided. The examples used were focused largely on capstone courses because <u>all</u> program outcomes are incorporated into these final projects. The capstone reports and presentations represent good examples of outcome assessment; they are a direct demonstration of what students are able to do or show by the time of graduation.

Outcomes Assessment Process

The assessment process through which we evaluate program outcomes occurs at different levels (individual courses and the program as a whole) and involves a variety of assessment tools. The goal of this process is to determine how close we come to achieving our program objectives.

At the individual course level, objectives and outcomes of each course, agreed on by the faculty, are defined in the individual course syllabi (see Appendix I-B).

Relationships of course objectives to the program objectives as well as expected outcomes (a-k Criteria) are indicated in brackets for each topic of the course. The relationship of course objectives and outcomes to program objectives and outcomes are shown in Appendix I-B. Direct assessment tools to measure the degree to which [illegible] achieved are also [illegible] way, [illegible] linked to (a[illegible]

[illegible] objectives and outcomes are [illegible] student feedback, ICES (end-of-semester) feedback, senior and alumni surveys and directly assessed via employer surveys. This feedback is evaluated by the de[illegible] [illegible] faculty at least once a year and changes are made whe[illegible]

[illegible]pment of Program Outcomes

Concurrent with the establishment of the ChBE program objectives, the program outcomes were discussed and established. The procedures used and constituent groups consulted during this process are identical to those [illegible] defining the program objectives; see th[illegible] [illegible]n. In particular, ChBE faculty [illegible] [illegible]ent Groups), the ChBE Extern[illegible] [illegible]r graduates aided in the establishm[illegible] [illegible]. The Figure below represents a schematic of the p[illegible] developing the p[illegible]

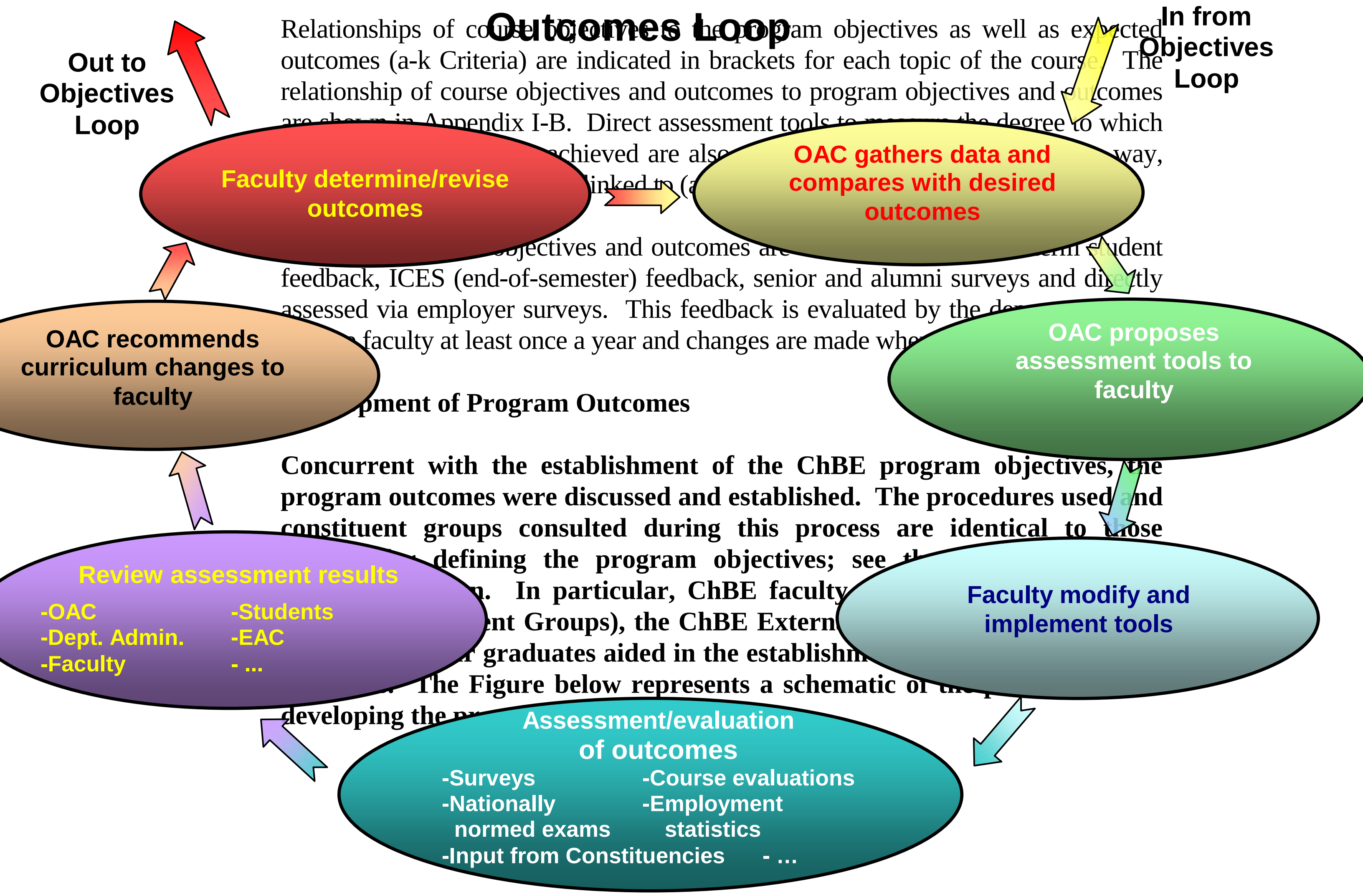

Figure 2: Schematic of process used to determine or revise educational outcomes. OAC = Outcomes Assessment Committee

Here, we start with our Program Objectives (developed though ABET (a)-(k) criteria) and faculty and the OAC determine appropriate outcomes that are testable and reasonable based on these objectives. The faculty implement these objectives throughout their courses and assess directly and indirectly students proficiency. Ability and proficiency are determined directly and in real time through tests, quizzes, reports, projects, presentations, homework, and standardized exams. Indirect measures are also employed to assess students' ability to achieve program outcomes. All of these data are reviewed by faculty and changes to outcomes, and therefore objectives, are made.

The convergence of ABET and our department objectives lists only occurred

after detailed and meaningful discussion. During the course of extensive discussions, we realized that we were generally making only minor wording changes to the ABET objectives and that outcomes naturally developed from them. We chose these objectives and outcomes because of our desire to coordinate with the College of Engineering where uniform criteria can be used for effective use of surveys. The Criteria 2000 Committee (C2K), consisting of a representative from each engineering department, organized by the College of Engineering, plays a leading role in coordinating the departmental efforts as well as gathering data (GRE, FE, EBI, and Employer data) common to all programs. These data are shown in the following sections.

Assessment of Outcomes

Students' achievement of outcomes is directly assessed through the tracking of student performance on homework, quizzes, reports, presnetations, projects, and exams. These assessment methods are broken down based on problem or section and each of these is linked to program and course objectives and outcomes. Where there are quantitatively-determined weaknesses seen across the entire class, input is sought from students or other faculty and changes are made to the course to better facilitate student success in the future. This process is described in detail, with example, in the next section.

For the Unit Operations course, assessment is performed via written test at the beginning of the course to track understanding gained from Biology, Chemistry, Reactor Design, Momentum Transfer, and Heat and Mass Transfer courses. Assessment of strength in the same areas (as well as many others) is performed at the end of the semester via written test to determine achievement of objectives. Weaknesses at the beginning of the semester are noted immediately by the instructor and are the subject of focus for the subsequent lectures. Severe weaknesses are almost always noticed during students' presentations, for which the instructor is always present. During this time, the instructor discusses with the students faulty reasoning or areas where there is lack of understanding.

Likewise, each section of reports submitted for the Process Design class is evaluated for acceptability. Many modifications were made to either more adequately communicate expectations or review material from other courses. So, with regard to direct assessment methods, oftentimes the course objectives did not change. What did change was the approach and emphasis on certain topics where students needed greater improvement.

For both Design and Unit Operations courses midterm feedback evaluation is performed at least once a semester. This allows students to re-structure both courses in real time to suit their learning styles and preferences. Changes to lectures, labs, and resource availability are implemented immediately. Students have remarked that they appreciate this immediate hands-on approach to tailoring their course experience.

Our curriculum and course objectives are indirectly measured and assessed by student surveys and employer surveys. The student surveys come in several varieties: Midterm Student Feedback, ICES (end of semester) evaluations, senior surveys, and alumni surveys. We have documentation of these survey results and this will be discussed in the next section. The department head and all faculty members are involved in evaluating these data and determining the appropriateness of making changes to the curriculum, facilities, and personnel. This feedback generally has resulted in the identification of the need for more project-based communication and teamwork emphasis in courses, which has been implemented in almost all courses since 2002. This has always been an emphasis in our course and program objectives, however through the feedback we receive we change the relative emphasis of one objective compared to another. Generally we have found that our present set of program objectives has continued to be appropriate for the constituencies that we serve.

Assessment of Outcomes Achievement Using Metric Goals

For Senior Design and Unit Operations courses, each outcome is linked to an assignment, project, test, quiz, or presentation that can be directly assessed. Each part of an assignment, project, test, quiz or presentation directly relates to course outcomes and objectives as well as a program outcome and objectives. Each course outcome is directly linked to a program outcome on each course syllabus, provided in Appendix I-B.

Since all assignments, projects, tests, quizzes, or presentations are related to course outcomes, each part can be tracked to determine whether student performance is acceptable or unacceptable. Instructors are therefore testing to see if course and program outcomes are being achieved on average in their classes. An example of this course/program assessment process is discussed here.

First, assignment, project, test, quiz or presentation grading rubrics are developed to assess performance. Through objective criteria, acceptable and unacceptable levels of achievement of outcomes can be determined. Sample grading rubrics and criteria for Senior Design and Unit Operations will be provided during the visit. A sample grading rubric for a Process Design Assignment is provided here. Note the percentage breakdowns for assignment of scores: