Annual Chemical Engineering ABET Report for 2007-2008

This report provides a summary of activities in the Department of Chemical Engineering at the University of Utah for the 2007-2008 academic year that had a direct or indirect impact on the academic mission, particularly as it affects undergraduate students.

Constituents, Mission, Objectives, Outcomes

The Department held a meeting of their eleven-member industrial advisory board on 2008 April 2. The board provided critical input on our program and resulted in changes to our list of constituents and educational objectives. The items below reflect their input.

Constituents

The list of constituents was expanded to include members of the Chemical Engineering faculty at the University of Utah. The revised list now reads as follows.

The Department has identified the following groups and institutions as its main constituents: students, industry, governmental agencies, academe at large, members of the Chemical Engineering faculty at the University of Utah, and alumni.

Mission

The mission of the Department of Chemical Engineering is to cultivate an environment through teaching, research, and service that fosters the technical, critical thinking, and communication skills necessary for students and faculty to contribute to the engineering profession and to the well-being of society.

Educational Objectives

The educational objectives were rewritten to put more emphasis on graduates contributing to their profession and succeeding in their chosen careers.

1. Graduates will contribute to their profession and succeed in their chosen careers.
2. Graduates will expand their knowledge and capabilities.
3. Graduates will be aware of issues that affect society and the world and will use this knowledge to strengthen their profession and contribute to the well-being of society.
4. Graduates will work effectively with others and practice ethical decision making.
Outcomes
The program outcomes are identical to those established by ABET in Criterion 3 for the 2008-2009 accreditation cycle.

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 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, 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.

Approach
Our approach to continuous improvement and ABET report preparation is summarized in Table 1. The task of data collection and reporting is spread over several faculty and staff.
### Table 1
Approach and assignments for assessment and reporting

<table>
<thead>
<tr>
<th>Assessment Tools</th>
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<tr>
<td>Interview workshop/recruiter feedback</td>
<td>JoAnn</td>
<td></td>
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<tr>
<td>Instructor surveys (every semester)</td>
<td>Geof</td>
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<td>Senior Exit Interview</td>
<td>Geof</td>
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<td>COOP employer survey</td>
<td>Terry</td>
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<tr>
<td>Course evaluations (base on ABET questions)</td>
<td>Jenny</td>
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<td></td>
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<tr>
<td>UG SAC - monthly meetings</td>
<td>Geof/JoAnn</td>
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<td>FE Examination Summaries</td>
<td>Jenny</td>
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<tr>
<td>Teaching Retreats</td>
<td>Geof/Michelle</td>
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<tr>
<td>Annual report from CLEAR</td>
<td>April</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Feedback Reports / Annual Reports</th>
<th>Objectives</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual curriculum report</td>
<td>Geof</td>
<td>X</td>
</tr>
<tr>
<td>Annual summary of faculty meeting minutes</td>
<td>Michelle</td>
<td>X</td>
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<tr>
<td>Annual report on IT</td>
<td>Brian</td>
<td>X</td>
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<tr>
<td>Annual report on advising</td>
<td>Jenny</td>
<td>X</td>
</tr>
<tr>
<td>Annual report on faculty (yearly mtg.)</td>
<td>JoAnn/Geof</td>
<td>X</td>
</tr>
<tr>
<td>Annual report on U of U infrastructure</td>
<td>Geof</td>
<td>X</td>
</tr>
<tr>
<td>Annual report on teaching labs</td>
<td>Bob/Geof</td>
<td>X</td>
</tr>
<tr>
<td>Annual summary of UG committee minutes</td>
<td>Geof</td>
<td>X X</td>
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<tr>
<td>AIChe annual report</td>
<td>Ed</td>
<td>X</td>
</tr>
<tr>
<td>Annual visitors and employers report</td>
<td>Geof/Michelle/JoAnn</td>
<td>X X</td>
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<tr>
<td>Graduate Council Review</td>
<td>Grad School</td>
<td>X</td>
</tr>
<tr>
<td>Annual summary on teaching retreats</td>
<td>Geof/Michelle</td>
<td>X</td>
</tr>
<tr>
<td>Annual report on IAB/ENAC</td>
<td>JoAnn/Geof</td>
<td>X X</td>
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<tr>
<td>Annual report on course evaluations</td>
<td>Jenny</td>
<td>X</td>
</tr>
<tr>
<td>Annual report on CLEAR</td>
<td>Geof</td>
<td>X</td>
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<tr>
<td>Annual summary on FE Examination</td>
<td>Jenny</td>
<td>X</td>
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<tr>
<td>Annual report on industrial relations</td>
<td>JoAnn</td>
<td>X X</td>
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<table>
<thead>
<tr>
<th>Annual Report</th>
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<tr>
<td>2004</td>
<td>Milind</td>
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<td>2005</td>
<td>Milind</td>
<td></td>
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<tr>
<td>2006</td>
<td>All/Geof</td>
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<tr>
<td>2007</td>
<td>All/Geof</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>All/Geof</td>
<td></td>
</tr>
<tr>
<td>2009 Self Study</td>
<td>All/Geof</td>
<td></td>
</tr>
</tbody>
</table>

Last revised: 2008 August 26

**Summary for 2007-2008**
The following summary is organized by the 9 criteria for baccalaureate-level programs. The summary includes findings and the responses to them. Not all of the criteria are included.
Criterion 1. Students. During the 2008-2009 school year, the GPA requirements for admission to full major status were increased from 2.3 to 2.5. Two additional changes were enacted: (1) No grade below a C- will be accepted in applications for Intermediate and Major Status. (2) No grade below a C- in required Chemical Engineering courses will count toward graduation. These changes were made to help decrease the number of students who are unable to pass the Fundamentals of Engineering Examination. A passing score on the general and discipline-specific portions of the FE is required for graduation.

Criterion 2. Program Educational Objectives. The objectives were revised based on input from the Industrial Advisory Board. The revisions emphasize the importance of graduates succeeding in their chosen careers. A survey of alumni conducted in April 2008 showed that most of our graduates feel the objectives are appropriate, most feel they are succeeding in their careers, and most are continuing to learn.

Criterion 3. Program Outcomes. The attainments of program outcomes (a - k) were assessed by a variety of methods including the FE exam, instructor surveys, final reports from the CLEAR program, feedback from the employers of our internship and co-op students, the senior exit interviews.

- The FE exam provides a comprehensive assessment of students’ level of achievement of outcomes. All of the graduating students from the Class of 2008 passed the general and discipline-specific portions of the FE. In looking at FE scores over several years, there are no discernable patterns in the subjects in which our students fall below the national average.

- The instructor surveys are completed each semester. A few of the instructors note some weaknesses in the skills of the students in the 2000- and 3000-level courses in (1) math, (2) writing, (3) design, (4) problem solving, and (5) the ability to find information. The College is working to address (1) and (2). The instructors are working to address all five by giving the students more practice in these areas. The Department has developed a schedule of classes to help coordinate interactions with CLEAR, the Center for Engineering Leadership in the College of Engineering.

- The 2008 CLEAR annual report criticized the Department for not having standardized formats for reports and for a lack of uniformity in expectations between lab instructors and CLEAR instructors. In response, the Department has revised the examples of reports that are available online, has revised its guidelines for literature references, and has developed the schedule noted above.

- The employers of our interns note a weakness in writing skills but these comments were primarily directed at students for whom English was a second language. The Department’s efforts to improve the writing of all students, as noted in the previous two items, should also help these students.
- Visitors from industry, many of whom are alumni, suggested that the department emphasize VBA with Excel, process economics, process control, process safety, and internships and deemphasize Physical Chemistry II and Biochemical Engineering. In response, Physical Chemistry II has been dropped from our program. The department is inviting recruiters from industry into our core classes to talk to students about internships. The co-op program is introduced in our introductory computing course, CH EN 1703, by students who have participated in the program, and VBA has been introduced in CH EN 3853, Chemical Engineering Thermodynamics.

- The Senior Exit interviews show general satisfaction with the development of professional skills in the department, including teamwork, communication, life-long learning, and an awareness of the impact of engineering solutions on society. The seniors believe internships are the best way to develop an appreciation for the importance of lifelong learning. All graduates of the Class of 2008 completed at least one internship or co-op.

  o **Criterion 4. Continuous Improvement.** Actions to improve the department are listed under Criteria 2 and 3 and are not repeated here.

  o **Criterion 5. Curriculum.** Roundtable discussions with visiting faculty suggest that our curriculum is comparable to that at other institutions. The companies that are hiring our students, Celanese in particular, seem pleased with the training that our students are receiving. Our program is unique in requiring two semesters of design.

  o **Criterion 7. Facilities.** The Senior Exit Interviews and input from the lab manager (Bob Cox) have pointed to the need for major improvements in the projects lab. Many of those needs have been addressed in the past year. The main accomplishments during the 2008 year include (1) improved ventilation and air conditioning, (2) new fume hoods and canopies for all lab stations, (3) complete renovation of the bioprocessing lab, (4) the installation of a new distillation column, (5) the installation of a new ultrafiltration process, (6) the consolidation of the projects and instrumental analysis labs, and (7) the reorganization of the project stations to improve safety and aesthetics.

  o **Criterion 8. Support.** Funding for the changes noted under Criterion 7 has come from State, University, and private sources. The Department’s development efforts have been particularly successful in connecting with alumni.

**Criterion 1. Students**

**Changes in Requirements for Intermediate Status, Major Status, and Graduation**

The Department raised the GPA requirement for Major Status from 2.3 to 2.5 and grades below a C- will no longer be accepted. Major status is based on three courses: CH EN 2703 (Numerical Methods), CH EN 2300 (Thermodynamics I),
and CH EN 2800 (Process Engineering). The increase in academic requirements was made in order to help ensure that our seniors can pass the FE Examination. A passing score on the FE is a requirement for graduation. The same increases in GPA requirements were approved for Intermediate Status. Intermediate Status is based on CHEM 1210 and 1215 (General Chemistry I and lab), MATH 1210 (Calculus I), CHEM 1220 and 1225 (General Chemistry II and lab), MATH 1220 (Calculus II), CH EN 1703 (Intro. to Engineering Computing), CH EN 4753 or 4755 (Undergraduate Seminar), PHYS 2210 (Physics for Scientists and Engineers I), and WRTG 2010 (lower-division writing requirement).

In addition, grades below a C- in required chemical engineering courses will no longer be accepted toward graduation. This policy does not apply to technical electives in chemical engineering but it does apply to transfer courses that are being substituted for required chemical engineering courses.

Change in Policy on FE Examination
The Department requires that our students pass the morning and afternoon (general and discipline specific) sections of the FE Examination in order to graduate. During the 2007-2008 year the Department approved allowing students who do not pass the FE after two attempts to petition the UG Committee for an exception to policy. The following wording has been added to the UG Handbook. “Students who do not pass the FE exam after two attempts are permitted to petition the Undergraduate Committee for an exception to policy.” During 2007-2008, one student was granted an exception.

The new policies noted above with regard to Intermediate Status, Major Status, and the unacceptability of grades below C- was enacted, in part, to help prevent putting seniors in the situation of not being able to pass the FE after having completed the required coursework.

Criterion 2. Educational Objectives

Revision of Objectives in Response to IAB
The educational objectives describe the career and professional accomplishments that our program is preparing graduates to achieve. Our objectives from the 2003 ABET review were put together without extensive review from industry. The Department’s Industrial Advisory Board (IAB) reviewed the objectives in April 2008 and helped us to arrive at the current set.

Two members of the IAB were particularly helpful in reformulating the objectives. Arnis Judzis and Jeff Siirola pointed out that a key objective should be the ability to function and succeed in a chosen career. Jeff suggested that we include a question in our alumni survey that asks how alumni have advanced in their careers. Jeff and Arnis went on to note that we can decrease the number objectives and that it is not necessary to repeat the outcomes in our list of objectives.
Finally, Jeff pointed out that the list of the Department’s constituents is missing a key member: the faculty members in Chemical Engineering at the University of Utah.

The Department revised its objectives and list of constituents as given on page one of this report.

**Spring 2008 Alumni Survey**

Eighty-five alumni were contacted by email and asked to take a web-based survey. Twenty-two responses (26%) were received during the period from May 22 to June 24. The graduation dates and educational histories of the 22 are summarized in Table 2. All received their BS in ChE from 2004 - 2006. Four have received MS degrees, three are currently PhD candidates, and one has graduated from medical school.

Table 2
Graduation dates and educational histories.

<table>
<thead>
<tr>
<th>Graduation Year/Degree</th>
<th>BS</th>
<th>MS</th>
<th>PhD</th>
<th>MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2006</td>
<td>11</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In progress</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Twenty alumni indicated that they are currently employed or in graduate school. Two did not respond to the question about current employment. Of the twenty who responded, three are in graduate school and one is doing their residency in pathology. Of the sixteen who report being employed, 15 appear to be working as engineers. Ten of the 20 have held engineering positions before their current position.

The department’s educational objectives are listed on page one. The first states that graduates will contribute to their profession and succeed in their chosen careers. This objective was indirectly addressed by asking alumni whether their careers were progressing as they would hope. Sixteen responses were received. With the exception of one person, the respondents seem pleased with how their careers have developed. One is clearly dissatisfied and believes that his company treats engineers like technicians. He does not feel he is growing as an engineer.
Alumni were directly asked about the importance and relevance of Objectives 2 - 4 (Graduates with expand their knowledge and capabilities; Graduate will work effectively with others and practice ethical decision making). The questions and responses are summarized in Table 3.

Table 3
Importance and relevance of educational objectives.

<table>
<thead>
<tr>
<th>Objective</th>
<th>1 - Unimportant</th>
<th>2 - Slightly important</th>
<th>3 - Important</th>
<th>4 - Very important</th>
<th>5 - Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>2--Graduates will expand their knowledge and capabilities.</td>
<td></td>
<td></td>
<td>63.6% (14)</td>
<td>36.4% (8)</td>
<td></td>
</tr>
<tr>
<td>3--Graduates will be aware of issues that affect society and the world and will use this knowledge to strengthen their profession and contribute to the well-being of society.</td>
<td></td>
<td>18.2% (4)</td>
<td>59.1% (13)</td>
<td>22.7% (5)</td>
<td></td>
</tr>
<tr>
<td>4--Graduates will work effectively with others and practice ethical decision making.</td>
<td></td>
<td>4.5% (1)</td>
<td>45.5% (10)</td>
<td>50.0% (11)</td>
<td></td>
</tr>
</tbody>
</table>

Most of the alumni feel that objectives 2 - 4 are very important or extremely important. Table 4 summarizes how they feel about the preparation they received for meeting the objectives. Most feel their preparation for Objectives 2 and 4 was good or outstanding. However, their feelings about Objective 3 show that 40% felt they received just adequate preparation.

Table 4
Preparation to meet educational objectives.

<table>
<thead>
<tr>
<th>Objective</th>
<th>1-Poor</th>
<th>2-Marginal</th>
<th>3-Adequate</th>
<th>4-Good</th>
<th>5-Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>2--Graduates will expand their knowledge and capabilities.</td>
<td></td>
<td></td>
<td>13.6% (3)</td>
<td>72.6% (16)</td>
<td>13.6% (3)</td>
</tr>
<tr>
<td>3--Graduates will be aware of issues that affect society and the world and will use this knowledge to strengthen their profession and contribute to the well-being of society.</td>
<td></td>
<td></td>
<td>40.9% (9)</td>
<td>50.0% (11)</td>
<td>9.1% (2)</td>
</tr>
<tr>
<td>4--Graduates will work effectively with others and practice ethical decision making.</td>
<td></td>
<td></td>
<td>13.6% (3)</td>
<td>54.5% (12)</td>
<td>31.8% (7)</td>
</tr>
</tbody>
</table>
Alumni were asked about the ways in which they have continued to expand their knowledge and capabilities. Alumni are relying on work experience, professional organizations, internal training, external training, graduate school, conferences, technical journals, trade journals, continuing education courses, text books, community groups, and general news publications to stay current and expand their knowledge.

In summary, the results of the survey strongly suggest that our objectives are relevant and being met. The following summary looks at the key results for each objective.

1. Graduates will contribute to their profession and succeed in their chosen careers.
   a. Sixteen alumni responded to the questions, “Is your career progressing as you would hope?” Only one of 16 expressed dissatisfaction with how their career has progressed.
   b. Twenty alumni indicated that they are currently employed or in graduate school. Two did not respond to the question about current employment. Of the twenty who responded, three are in graduate school and one is doing their residency in pathology. Of the sixteen who report being employed, 15 appear to be working as engineers. Ten of the 20 have held engineering positions before their current position.

2. Graduates will expand their knowledge and capabilities.
   a. Of the 22 alumni, 4 have earned MS Degrees, 3 are working on PhD’s, and one has graduated from medical school.
   b. Alumni are relying on work experience, professional organizations, internal training, external training, graduate school, conferences, technical journals, trade journals, continuing education courses, text books, community groups, and general news publications to stay current and expand their knowledge.

3. Graduates will be aware of issues that affect society and the world and will use this knowledge to strengthen their profession and contribute to the well-being of society.
   a. More than 70% of the alumni feel this objective is very important or extremely important.
   b. Forty percent feel their preparation in this area was only adequate. Of the three objectives with numerical results, this was the area where students felt least prepared.

4. Graduates will work effectively with others and practice ethical decision making.
   a. Ninety-five percent of the respondents feel this objective is very important or extremely important.
   b. Eighty-seven percent feel they were well prepared for this objective.
**Criterion 3. Program Outcomes**

**Alumni Survey**
Eighty-five alumni were contacted by email and asked to take a web-based survey. Twenty-two responses (26% of 85) were received during the period from May 22 to June 24. The graduation dates and educational histories of the 22 are summarized in Table 2.

The survey included an open-ended question asking for general suggestions on how to improve the chemical engineering program at the U. A dominant response is the need for more emphasis on industrial practice and the importance of relating teaching to industrial practice. The importance of internships is also mentioned. The detailed responses follow.

1. Continue encouraging and helping students to gain real-world experience through internships and co-op programs. Overall it was a good education.
2. It's an excellent program.
3. Mentoring: from upper division to lower and from industry to upper division. More projects, less exams.
4. It is a great program and the faculty possess a wealth of knowledge. I appreciated the small classes and the love that the professors had to teach and to watch their students learn. I suggest improving real engineering experiences related to the coursework and helping students research different industries so that they have a better idea what an engineer would do in those industries.
5. I understand the importance of teamwork. However, sometimes there is too much emphasis on team building and other aspects of education are forgotten.
6. I think there should have been more industrial links to the BS program. It seems like, from a student's point of view, that it is all about research. I realize that is what universities do, but I would have liked some more plant or industry exposure.
7. Knowledge is extremely important but the ability to communicate, to work efficiently, and to document your work are also essential. Knowledge + Excellent Communication/Documentation Skills + Good Work Efficiency = Fantastic Engineer.
8. I felt that the senior lab was under utilized. I thought that it would have been a good experience to have worked with the heat exchanger or heat flow bench while in heat transfer or done something with the distillation column while in Mass transfer and so on. I would also have benefited from having more instructors. I had one instructor for three different classes and I did not learn well from his teaching style.
9. Increase the number of projects for the students to learn through hands on experience. Decrease the number of papers that are written.
10. Provide students with information on "out of the box" job opportunities. I felt like I was exposed to the traditional chemical engineering careers but not really given any stimulus for non-traditional ways of applying my degree.
11. Consider getting input on how to improve the department from a small number (three) of recent graduates. Could they team teach a course with a regular faculty member?

With regard to helping future student to meet the educational objectives, several alumni mention the importance of industrial practice, internships, and relating teaching to industrial practice. Two mention the desirability of exposing students to VBA and MS Access. One mentions process safety. Another stresses the importance of being able to communicate with people of diverse backgrounds. One suggests a better understanding of business practices. Finally, one alumnus pleads for more open-ended courses like Design II where you are given the opportunity to think and explore.

Instructor Surveys
The instructor surveys are conducted at the end of each semester (Fall 2007 and Spring 2008). The surveys are intended to gauge how well students are meeting the outcomes based on their performance in core chemical engineering courses. Three slightly different surveys are sent to instructors depending on whether their course emphasizes lab work (CH EN 4903, 5), design (CH EN 4253, 5253), or core subjects (CH EN 2703, 2800, 3353, 3453, 3603, 3853, 4203, and 5103). All surveys are based on a three-point scale: 3 = strong, 2 = acceptable, 1 = weak.

Table 5 summarizes the responses for the core subjects. The instructors are asked to indicate the metric they used for their rating and to make comments. Table 6 gives the results for the two design courses. Table 7 summarizes the responses for the two projects laboratories. There were two sections for each lab for a total of four instructors.

In summary, our students have acceptable skills in the seven outcomes surveyed. They appear to be particularly strong in oral communication. Some of the 2000- and 3000-level courses show weaknesses in mathematics, writing, design, problem solving skills, and the ability to find information. This is to be expected in 2000- and 3000-level courses.

Comments from the instructor of CH EN 3853 (Chemical Engineering Thermodynamics) point to a disturbing weakness in basic calculus. He reports that many students struggle to take derivatives and to understand their meaning. This is particularly true of partial derivatives and of the concept of setting a derivative to zero to obtain a minimum or maximum.
Table 5
Assessment of Outcomes Based on Core UG Courses. Score: 3 = strong, 2 = acceptable, 1 = weak

<table>
<thead>
<tr>
<th>Outcome</th>
<th>2703</th>
<th>2800</th>
<th>3353</th>
<th>3453</th>
<th>3553</th>
<th>3603</th>
<th>3853</th>
<th>4203</th>
<th>5103</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Ability to apply mathematics, engineering, and science - problem solving skills.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.13</td>
</tr>
<tr>
<td>2) Ability to design a process to meet desired needs within realistic constraints.</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.00</td>
</tr>
<tr>
<td>3) Ability to communicate in writing.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.88</td>
</tr>
<tr>
<td>4) Ability to communicate orally.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.00</td>
</tr>
<tr>
<td>5) Ability to work in teams.</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2.38</td>
</tr>
<tr>
<td>6) Ability to understand the role of engineering in society.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.00</td>
</tr>
<tr>
<td>7) Ability to perform research, learn new concepts, and find information.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1.86</td>
</tr>
</tbody>
</table>

Table 6
Assessment of Outcomes Based on Senior Design Courses. Score: 3 = strong, 2 = acceptable, 1 = weak

<table>
<thead>
<tr>
<th>Outcome</th>
<th>4253</th>
<th>5253</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Ability to apply mathematics, engineering, and science - problem solving skills.</td>
<td>2</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>2) Ability to design a process to meet desired needs within realistic constraints.</td>
<td>2</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>3) Ability to communicate in writing.</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4) Ability to communicate orally.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) Ability to work in teams.</td>
<td>2</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>6) Ability to understand the role of engineering in society.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>7) Ability to perform research, learn new concepts, and find information.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 7
Assessment of Outcomes Based on Senior Projects Laboratory. Score: 3 = strong, 2 = acceptable, 1 = weak

<table>
<thead>
<tr>
<th>Outcome</th>
<th>4903</th>
<th>4903</th>
<th>4905</th>
<th>4905</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Ability to apply mathematics, engineering, and science - problem solving skills.</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>2) Ability to design and conduct experiments and analyze data.</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>3) Ability to communicate in writing.</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.25</td>
</tr>
<tr>
<td>4) Ability to communicate orally.</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2.75</td>
</tr>
<tr>
<td>5) Ability to work in teams.</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2.00</td>
</tr>
<tr>
<td>6) Ability to understand the role of engineering in society.</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.25</td>
</tr>
<tr>
<td>7) Ability to perform research, learn new concepts, and find information.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Input from Practicing Engineers at Celanese

A number of our alumni are employed by Celanese and visit the University of Utah on a regular basis for the purpose of recruiting students for internships and regular positions. The comments of these alumni, made during 2007-2008, are gathered here.

From Kelly Wallace (Class of 1991)

1. Additional experience in public speaking, developing concise presentations, and professional social interactions (e.g. interviewing, ice-breaking conversations, etc.) can always be of benefit to a graduating student.
2. U of Utah is definitely industry-friendly and gears their students to become effective employees. One area of opportunity is to stress the importance of summer internships and/or co-ops such that the student gains valuable industrial experience.

From Brandon Grimm and Stan Holbrook (Class of 2006)

1. Subjects to consider emphasizing more in our curriculum.
   a. Process safety (Brandon is working in this area).
   b. Brandon believes he would have found parts of Air Pollution Control Engineering useful because of his work in process safety. He did not take this course.
   c. Brandon believes we should be teaching our students how to use VBA (Visual Basic Applications) in Excel.
   d. Process economics and a strong background in control are important.
2. Their suggestions for items to eliminate or deemphasize in our curriculum include
a. Drop the second semester of physical chemistry (thermodynamics and kinetics). Stan was aware that we had already made the second semester optional.

b. Brandon has not found biochemical engineering useful.

3. Both felt that we do not need to emphasize statistics more than we do because they receive six-sigma training at Celanese.

4. Both felt they were well prepared in oral and written communication.

JoAnn and Milind met with several alumni at Celanese in Clear Lake, Texas. JoAnn’s notes include the following points.

1. Students with a process control background are really needed. Advanced methods and distance control techniques were mentioned.

2. We need to incorporate more process safety in our classes (perhaps Celanese can help us with this?).

3. Our students need more internship and coop experience. JoAnn stated that we need more opportunities for these.

4. Process economics is important. This is a difficult one to assess because, as Celanese notes, the economics are process dependent. The underlying principles are needed, however.

**Input from Chevron Refinery Manager**

Two extended conversations were held with Steve Klasnich (Technical Manager, Chevron Product Company, Salt Lake Refinery) He reviewed (1) our 2005-2006 ABET report that included our objectives and outcomes, (2) the Fall 2006 Internal Review, and (3) the Fall 2006 External Review. The internal and external reviews were part of the Graduate Council Review of Chemical Engineering.

In reviewing the 2005-2006 ABET report, Steve emphasized his agreement with the comments made by the employers of our cooperative education and internship students. He stressed that students need to know the importance of continued learning in an “on-the-job” situation. Most companies cannot afford formal training of new employees.

We spent several minutes discussing open-ended problems and how to expose students to the competing requirements that are part of engineering. How can we teach students the ability to handle competing priorities? This led to a discussion of the importance of communication particularly with regard to the need to be able to (1) explain how you arrived at your solution, (2) defend what you have done, and (3) convince others that your idea is worth trying.

I mentioned the recommendation of the Graduate Council Review that we include a biology course in our curriculum. Steve suggested that there is enough flexibility in our curriculum through technical electives to allow interested students to pursue biology courses. He recommended that we consider providing
undecided students with an aptitude or assessment test to help them pick a specialty. This could be a way to strengthen our career advising process.

In a second meeting with Steve, we discussed a wide range of topics that focused primarily on people skills and on helping students decide what area of ChE they want to specialize in, if any. The latter included the need for helping younger students (first and second year) understand what it means to practice chemical engineering. JoAnn particularly liked the idea of having a seminar series for second-year students.

The people skills we discussed included (1) knowing how to talk to people at all levels (operators, plant managers, technicians, engineers); (2) being able to create and work within a collaborative, cooperative environment; (3) the ability to merge technical, communication, and social skills; and (4) having the skill and confidence to work within deadlines.

A European Perspective: Lars Stromberg, Vattenfall Group

Prof. Stromberg is an adjunct professor at Chalmers University, Department of Environmental and Energy Technologies, Sweden and a VP with the German energy company, Vattenfall Group.

Lars noted that there is a shortage across Europe of engineers trained in basic energy engineering topics: thermodynamics, fluid mechanics, and heat transfer. Professors have also lost these basic skills. Lars attributes this partly (at least in the UK and Germany) to the overemphasis on publications at universities with little recognition for other qualities. This is making it difficult to respond to the need for energy engineers - engineers who can work on energy issues. There is a need for industrial people to return to the universities in the EU to teach applied energy engineering.

Lars pointed out that students are helping to renew the interest at universities in energy because they are interested. There is also a general recognition among these students that technology and engineering are not necessarily bad.

Input from Professors from Other Universities

The meetings that are summarized below occur as part of our Distinguished Lecture Series. Each speaker is invited to a roundtable discussion with the faculty. These allow us to look at what other schools are doing with their undergraduate and graduate programs. Their input on curriculum is particularly useful in determining how our approach compares to what others are doing.

Roundtable with James Hill, 2007 October 16

James is University Professor and Chair of Chemical & Biological Engineering at Iowa State University. Iowa State graduates 60-80 undergraduates per year.
They have roughly 400 undergraduates in their program. About half of their faculty are in the biological area.

During the roundtable he noted that the market for chemical engineers is changing and that most of Iowa State’s graduates are going to the petrochemical industry. He attributes the dominance of this tradition path to the retirement of older workers in that industry. He is also seeing a few students going to electronics.

Roundtable with Robert Davis, 2008 January 22

Robert is Dean of Engineering at the University of Colorado, Boulder. Prior to becoming Dean he was the Chair of Chemical Engineering at Boulder. During his tenure as chair, his department went from being known for their undergraduate program (Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, for example), to being known for their research and graduate program. The biggest change they made was to raise the quality of the graduate students. The second key factor was the hiring of strong faculty and supporting them. The ChE Department has 6 endowed positions to help retain outstanding faculty. That is 6 out of 18 positions.

They currently have about 90 graduate students and roughly 15% are international. Colorado guarantees their support for 5 years. Few students are from Colorado. The average undergraduate GPA of the incoming graduate students is 3.8. Many have NSF and similar fellowships.

The undergraduate program is still strong and did not suffer as a result of these changes. Colorado graduates about 100 students per year. They have added a Chemical and Biological B.S. Degree. They have good faculty-student relations and a strong UG research program. On average, each faculty member has 5 UG students in their lab. They have a college-centralized undergraduate research program. They also have a college program that uses upper-division students to help teach lower-division classes and perform K-12 outreach. This is called Earn and Learn.

Roundtable with Stacey Bent, 2008 February 19

Stacey is a professor of chemical engineering at Stanford. The department is small (12 faculty) and has built on its strengths. They focus on biological engineering, materials, and nanotechnology. Their recent hires are at the periphery of the department’s strengths. They have strong interactions with the departments of biology, materials science, and electrical engineering.

Stanford’s UG curriculum is evolving but their core is still fairly traditional. They have a strong emphasis on biomolecular engineering and require a junior-level biochemistry course that they teach themselves. They have a second bio-course
taught in the senior year. They try to include bio-based problems and examples in all of their courses but they notice that the students want more emphasis on energy and materials. They do not teach a separate course in numerical methods but try to include problems that require numerical solutions in all of their courses. They have not standardized on a single mathematical software package. The unit operations lab uses primarily small-scale equipment with an emphasis on biological processes. They have a one-quarter-long seminar course with guest speakers from industry, focused on careers in ChE. This is one evening a week with dinner.

Stanford's undergraduates don't declare their major until half-way through the 2nd year. Many of their undergraduates are involved in research in the department and many participate in summer internships with industry. About one-third participate in a BS/MS degree program. The MS is non-thesis.

The graduate program includes about 100 students with almost all being PhD candidates. The graduate core consists of applied math, fluid mechanics, two quarters of biological science, and two quarters of quantum and statistical mechanics with applications to spectroscopy.

Stacey discussed the retention of female faculty and emphasized that this effort needs to be university-wide. She said it is good to have at least two female faculty in a department if possible. A major concern is with childcare. It is so beneficial if childcare is available on campus. Another major concern is how to care for children with all the necessary travel to conferences.

Roundtable with Charles Zukoski 2008 March 3

Charles is the Vice Chancellor of Research at the University of Illinois (Urbana-Champaign). He believes that the winds of globalization are coming to universities. He wonders if our universities should be more focused on economic development.

He mentioned that they have established a new research park. The companies that are moving in are not that interested in access to faculty - they want to hire students.

Charles wanted to talk about the future of the ChE discipline but there was not time. He did say that he doesn't know where it is going.

Roundtable with Carol Hall 2008 March 11

Carol is a Professor of Chemical Engineering at North Carolina State. We started with a discussion of computing in the chemical engineering curriculum. She noted that the trend is to add more computing but she feels that adding too much obscures the basics. So she keeps things simple in her own teaching
(Engineering Thermodynamics and Chemical Engineering Thermodynamics) and avoids complex computing. She agreed that programming has pedagogical value because it teaches careful thinking. She is writing her own text on thermodynamics and believes that the organization of the text is the key to success. She has not introduced biological problems in her thermodynamics courses.

Her department has not adopted a uniform computing platform like MATLAB. One instructor is using VBA. They use ASPEN.

Carol says that NSC has actually hired people to help faculty bring computing into the curriculum. Phil Smith noted that engineering and the associated simulation inherently involves multiple scales and multiple branches of physics. He wonders if we are addressing this aspect of computing in engineering.

NC State used to graduate 120 undergraduates per year. That number has declined precipitously in recent years. Her department has responded by adding the word biomolecular to their name. Since that change, the graduation rate is back to 100 per year. They have not changed the basic courses in their department but they have four tracks: traditional, nanotechnology, biomolecular, and biomanufacturing technology. Carol would like to see her department teach a course in “everything you wanted to know about biology but were afraid to ask.” They offer one bioseparations course.

Carol added that she likes what we are doing with CH EN 5103, Biochemical Engineering. She said this after Ed explained that the first four weeks of 5103 provide an overview of molecular biology.

Carol wonders if we (as instructors at all universities) should be covering less and going into more depth. She is not doing this but keeps wondering.

Roundtable with Pratim Biswas 2008 April 8

Pratim is Professor and Chair of Energy, Environmental, and Chemical Engineering at Washington University. We spent a long time discussing how their department has evolved and on how it got its name. Phil raised a question about the change in ChE discipline and asked if we are in danger of losing who we are. He was glad to see that Pratim’s department at least lays claim to energy.

With regard to curriculum, Pratim noted that they have abandoned a “transfer phenomena” approach at the undergraduate level. They now teach separate courses in fluids, heat transfer, and mass transfer. They have a mass transfer operations course that is in addition to a mass transfer course.
Summary of Senior Exit Interviews

The following summary of the 2008 Senior Exit Interviews focuses on responses that relate to Criterion 3, Program Outcomes. The Chair and Associate Chair interviewed 22 students. Of these, 19 graduated in May 2008 and three in August 2008.

1) **Experiences with Communication.** The students generally feel they are getting plenty of experience but recommend that the communication experiences and interactions with the CLEAR Program (Communication, Leadership, Ethics, and Research) be spread out over more of the curriculum so that things are not so concentrated in the senior year.
   
a. The students' comments on CLEAR are mixed. Many felt CLEAR was helpful but several felt otherwise. Several question why CLEAR is involved at all. One person called it childish. Two seniors suggested that CLEAR's effectiveness would improve if their instructors had more engineering background. One called CLEAR overzealous. Another commented that the CLEAR instructors have a hard time communicating with the students and that they simply restate what the students already know.
   
b. A common remark was that the lab instructors and CLEAR instructors need to communicate better with each other so that they are in sync. The professors need to make their expectations better understood by the students and by the CLEAR staff.

2) **Broad education and impact of engineering solutions on society.** The seniors generally feel we are succeeding at getting them to think about the local and global impacts of engineering solutions on people and society, particularly through courses like Ethics in Engineering; Air Pollution Control Engineering; Seminar; Cooperative Education; and Law, Engineering, and the Environment. With the exceptions of Dr. Roper and Dr. Eddings, the instructors of our core classes do not seem to be making the connection between engineering and society.

3) **Life-long learning.** The students recognize the need for life-long learning most clearly through their cooperative education, work, and internship experiences. All of the 2008 students have had one or more internships or coops.

4) **Contemporary issues.** The students' responses suggest that this is an area where some improvement is needed. Several comment on how Dr. Roper brings newspaper clippings to class (Design I). Dr. Tyler, (Heat Transfer), Dr. Skliar (Control), Dr. Trujillo (Bioprocess), Dr. Silcox (Air Pollution), Dr. Eddings (Fluids and Kinetics), and Dr. Krahenbuhl (Nuclear) are also mentioned for bringing in contemporary issues. Some seminars also succeeded at this. Jeff Sirola's April 2008 seminar on using coal as a chemical feedstock is specifically mentioned.

5) **Teamwork.** Teamwork experiences are plentiful and generally positive. One female student noted gender issues and a second female said that with some teams she felt left out, neglected, and ignored. Two students mention that the
CLEAR teamwork instructor, Autumn, has not been well received. One suggested that she “tone down her flowery language.”

6) **BS Thesis.** One student completed an honors thesis and thought it was a great capstone experience.

7) **Interactions with practicing engineers.** Several seniors point out the importance of internships and coop’s as a means of getting to know practicing engineers. One student asks that we do more to encourage students to participate in internships and that we find more internships for 2nd-year students. Several mention seminar and the AIChE Lunch & Learn or Brown Bag lunches with industrial visitors. Two students mention the need to keep seminar balanced between industry and academe.

8) **Interactions with potential employers.** Most students feel that interactions with potential employers are good but could be better. Two mention the BYU career fair and wonder why they had to go there to meet employers. Two students mention the need to keep seminar balanced between industry and academe. The emails sent by Jenny (and Leda) are helpful in finding employment. One student suggests the development of an alumni network to help with finding more internships.

9) **COOP, summer internship, undergraduate research.** All of our 2008 graduates had at least one COOP or internship. In addition, 7 had some type of research experience, usually with a ChE professor.

10) **Suggestions to improve any aspect of Chemical Engineering Program.** Common themes are summarized below.

   a. Students need to be given an overview of the ChE profession in 1703. What is chemical engineering all about and what kind of impact can a chemical engineer have? Some feel that the emphasis on computing and MATLAB in 1703 is driving students away. If the Department is going to use MATLAB, then it needs to be used throughout the program so that it can be learned and retained. If MATLAB is not going to be used throughout, then consider shifting to Excel, Visual Basic Applications (VBA), Polymath or similar programs.

   b. The senior lab equipment needs to work better. More interesting experiments and projects are also needed.

   c. Some of the core classes are too theoretical and would benefit from more applications. This criticism was directly primarily at Process Control. In general, instructors need to help students understand the usefulness of what they are learning.

   d. Too many instructors’ exams do not reflect what was covered in lectures or homework.

11) **Student Chapter of AIChE.** Students’ experiences with AIChE are mixed. Many have had no involvement. Several mention their involvement with the ChemE Car, field trips, and lunches. One student asks for more activities that benefit them academically and professionally. About half plan to maintain their membership in AIChE.
In summary, the Class of 2008 graduating seniors suggest that the Department (1) work to incorporate more contemporary issues in courses, (2) improve coordination with CLEAR, (3) strive to improve the quality of the lab equipment, (4) ensure that courses include enough practical applications so that students can see the usefulness of what they are learning (1703 and 4203 are specifically mentioned), and (5) continue to emphasize the importance of cooperative education and internships.

**Evaluation of COOP Students by Employers**

Nine employers completed surveys for 2007-2008

The questions on the survey are given below. Beneath each question I have recorded comments and suggestions for change. I have recorded the initials of the intern and the company they worked for.

1. Skills Mastery
   a. What technical skills does the student contribute to your organization?

   (BF, URS) The ability to think about a problem in terms of basic science and engineering principles.

   (MT, GE-Betz) Mastery of sampling and lab techniques for refinery specialty chemical business. MT understands chemistry applications and adjustment needed.

   (TD 1, Ceramatec) Chemical engineering: process flow diagrams, analytical mathematics.

   (TD 2, Ceramatec) Chemical engineering.

   (SH, JR PROPO) Chemical engineering: process design and control. Some translation work.

   (HM, GE) The single thing that characterizes HM is that he was quick to grasp new technical concepts regarding our work in electrical power plant design and analysis. His computer skills were quite good. These both enabled him to quickly learn and be productive with Visual Basic for Applications (VBA).

   (KR, Kimberly-Clark) Very good analytical and problem solving skills. Very strong oral communication and technical skills. Spends time on the floor working with process specialists and engineers to understand packaging processes. Developed metrics to measure bag quality attributes that previously were left too general to quantify (edge curl, bag wicket skew, etc). Uses software effectively to create good visual aids/diagrams in Excel and PowerPoint. Final static study report was
thoroughly written, well supported with facts and JMP data analysis, and include thoughtful next steps.

(CB, Data-Chem) Excellent knowledge of chemistry, MS Word, Excel. Knowledge of preparation tools (balances, pH meter, pipettes, microsyringe, volumetric glassware, etc.). Knowledge of LC instruments and maintenance. Knowledge of data analysis including Agilent ChemStation, old DOS-based and new Windows-based programs.

(KP, National Semi-conductor) Innovation, documentation, research capability.

(EM, CEntry) EM showed good fundamental knowledge and good computer skills. He was able to apply chemical engineering fundamentals to his work assignments.

b. What personal attributes does the student demonstrate, i.e., leadership, team player, organizational, work ethic, etc.?

(BF, URS) Strong work ethic and able to work independently. Self motivated.

(MT, GE-Betz) MT is highly organized and responsible. He is willing to do whatever is asked of him.

(TD 1, Ceramatec) Good team player, organization, work ethic.

(TD 2, Ceramatec) Team player.

(SH, JR PROPO) Leadership and diplomacy with the other students. Demonstrated a good work ethic and teamwork.

(HM, GE) This is another strong point. HM fit in well with our team and had opportunities to interact with every member. He was also extremely conscientious.

(KR, Kimberly-Clark) Great participation in meetings. Explains herself well in teleconferences. Gave an effective stand-up presentation to a large Six Sigma group soon after joining the team. Invites others (even senior engineers) when she feels it would benefit them. Worked with AS (experienced with trial planning) to flesh out static trial plan, developed mini studies, and determined appropriate sample sizes. Worked closely with electrical engineers to troubleshoot and correct “bag missed” data when issues were found.
(CB, Data-Chem) Leadership, team player, organizational, work ethic.

(KP, National Semi-conductor) Creative, works well in a group, ambitious, thorough, open minded. KP sees the big picture, not just what I’ve told him to look for.

(EM, CEntry) EM was a self-motivated worker, he made suggestions on ways to improve some of our form preparation and independently developed a cost/benefit analysis of commercial CFD software.

2. Preparation by University
   a. How well prepared is the student?

(BF, URS) Very well. It is clear that BF has received strong technical training.

(MT, GE-Betz) MT seems to understand all the fundamentals of chemical engineering to the extent I have observed. I believe he is very well prepared to be successful.

(TD 1, Ceramatec) Very good technical skills.

(TD 2, Ceramatec) Adequate.

(SH, JR PROPO) Technical skills were relatively good. Good overall knowledge of engineering topics. Should be well prepared for a successful career.

(HM, GE) HM’s educational background was well-suited for his assignment.

(KR, Kimberly-Clark) KR has very strong oral communication and technical skills. She quickly became a productive and respected member of the team and is unafraid to think outside the box and share her ideas.

(CB, Data-Chem) Well prepared. I would recommend English class for writing scientific papers. Otherwise well prepared.

(KP, National Semi-conductor) KP is very well rounded. He can do research as well as general process improvements that benefit real-world activities.

(EM, CEntry) Good preparation in fundamentals.

b. Suggested changes in curriculum?
(BF, URS) More emphasis on writing.

(MT, GE-Betz) None.

(TD 1, Ceramatec) More independent projects and time management.

(TD 2, Ceramatec) More independent projects, better technical writing, improved time management.

(SH, JR PROPO) Technical writing and broader applied knowledge of engineering.

(HM, GE) A graduate who arrives with a good combination of communication, engineering, and computing skills can be quite successful. In the area of computing, I believe that being an expert in Excel - the type of person whom people ask for help, is able to write Visual Basic macros, and so on - can prove to be a valuable asset in many fields.

(KR, Kimberly-Clark) None.

(CB, Data-Chem) Recommend English class for writing scientific papers. All students need hands-on work with modern instruments and software in a real-time atmosphere around real-world businesses and real-world environments.

(KP, National Semi-conductor) Real world value. Their ability to make cost effective decisions will determine their success in the world. This may mean business or economics classes. All engineers are in the business of making money. They need to understand that.

(EM, CEntry) Continue to emphasize a good, solid fundamental base in chemical engineering.

3. Corporate Culture
   a. Does the student understand the goal of the organization and their role in its success?

   (BF, URS) Yes. Consulting can be a difficult environment, but BF adapted well to the pressure of working under a client-driven business model.

   (MT, GE-Betz) Yes.

   (TD 1, Ceramatec) Yes. She successfully completed all her tasks.
(TD 2, Ceramatec) Yes.

(SH, JR PROPO) Yes.

(HM, GE) Henry fit into our corporate culture quite well. He appreciated the value of the tasks he performed and in doing so made a positive contribution to our team.

(KR, Kimberly-Clark) She quickly became a productive and respected member of the team and is unafraid to think outside the box and to share her ideas.

(CB, Data-Chem) Yes. The goal is to provide quality analytical chemistry services on time and ultimately profitably. The organization hopes to provide a stimulating workplace that provides personal growth for employees.

(KP, National Semi-conductor) We haven’t gone there yet because of the limited amount of time available from KP.

(EM, CEntry) EM seemed to grasp the role of the process engineering group in relation to the overall company strategy.

b. How does the student measure up to existing employee standards? If a job were available when the student graduates, would you offer a full-time position?

(BF, URS) BF definitely measure up well. He would definitely be considered as a candidate for hire.

(MT, GE-Betz) If I had a chemical engineering opening I would offer it to MT. As it is, the two customers he helps us with both made good offers to him.

(TD 1, Ceramatec) Very well. She interviewed for a position at Ceramatec.

(TD 2, Ceramatec) Was instrumental in winning a Phase 2 project. Projects well at next level and would recommend.

(SH, JR PROPO) Measures very well against existing employees. Wouldn’t hesitate to offer a position if available.
(HM, GE) I cannot comment on whether a position would be offered upon graduation, but I would personally welcome the opportunity to interview him should he have interest in the future.

(KR, Kimberly-Clark) Not addressed.

(CB, Data-Chem) Chris has worked here a year and a half. He long ago learned the basics of the required methods and employee interactions. The company would offer him a full-time position but they cannot compete with other industries monetarily.

(KP, National Semi-conductor) Would offer him a job in a heartbeat, but I believe KP is capable of greater things!

(EM, CEntry) As expected, EM required a fair amount of coaching and direction, but was able to make meaningful contributions. I would certainly be interested in hiring him full-time after graduation.

c. As an experienced professional in a field related this student’s area of study, you have valuable insights into what is required to be successful on the job. What advice would you give that would contribute to his/her preparation for a chosen career?

(BF, URS) IMPROVE YOUR WRITING! Being able to perform calculations and develop designs are not enough. Real success is more easily attained if you can also write clear explanations of difficult technical issues.

(MT, GE-Betz) Keep the positive, can-do attitude. Work hard, be creative, get the job done.

(TD 1, Ceramatec) The ability to manage your time and work successfully on multiple projects will increase your value to your current and future employers.

(TD 2, Ceramatec) It is important to feel personally vested in your job to make sure you enjoy what you do. Find a job you have a passion for.

(SH, JR PROPO) Look at the overall goals of a company/industry and make sure you have the same goals. Continue learning and growing; leap forward!

(HM, GE) These comments are addressed to all students. Since it is hard to predict what field you’ll be working in, and what role you’ll have in that field, study topics that have wide-ranging applicability. I strongly
advise design of experiments and numerical optimization methods; these can change the way you view engineering. Take every opportunity to develop presentation skills. Hone email skills - write emails that demand to be read.

(KR, Kimberly-Clark) Not addressed.

(CB, Data-Chem) The student has to be truly interested in the work. Trying to cross train someone from the arts or unrelated fields usually doesn’t work out. The person must have confidence and willingness to try new things. Finally, they must understand and implement the human side of the equation. CB does this.

(KP, National Semi-conductor) The #1 job of 99% of the organizations on the planet is to make money. They need to understand that first, then figure out how technical knowledge and its application gets you there.

(EM, CEntry) Solid in fundamentals of all engineering disciplines, a basic understanding of business principles, good writing and communication skills, ability to work according to established “good engineering practices”, and most of all, the desire and ability to continue to learn throughout ones career.

Conclusions

The employers of our cooperative education students are generally pleased with their quality. Of the suggested changes in our curriculum, more emphasis on writing is mentioned in connection with four of nine students. Note that two of the four interns about whom this comment was made were international students from Asia. The supervisor from Ceramatec twice mentions the need for more independent projects and improved time-management skills. The supervisor from General Electric (GE) mentions the “good combination of communication, engineering, and computing skills….“ He goes on to state the importance of being an expert in Excel and specifically mentions the ability to write Visual Basic macros.

FE Examination Summary

Twenty-four of our students took the Fundamentals of Engineering (FE) exams in either October 2007 or April 2008. All passed the exam. Of these, 23 were graduating seniors and one was a junior. Nationally, 998 chemical engineering students took the 2007-2008 exam and 861 passed (86%).

The subject areas in which U of U Chemical Engineering students performed better than or equal to the national average are listed in Table 11. The U of U students were particularly strong in design, economics, fluid dynamics, chemical
reaction engineering, heat transfer, and computing. Table 12 lists four areas in which our students were below the national average. These include material and energy balances, process control, material properties, and engineering thermodynamics.

Based on the analysis of scores from previous years, there are no discernable trends from year to year. For example, in 2006-2007, 29 students took the test and three failed. In addition, the areas with below average scores were extensive: Eng. Prob. & Stats, Chemistry, Computers, Eng. Economics, Eng. Mechanics, Material Properties, Electricity and Magnetism, Material/Energy Balances, Fluid Dynamics, Mass Transfer, Comp Usage and ChemE, and Safety, Health & Environment. The consistent appearance of Energy and Material Balances is cause for concern.

<table>
<thead>
<tr>
<th>Subject</th>
<th>UofU % Correct</th>
<th>National Avg. % Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>74</td>
<td>68</td>
</tr>
<tr>
<td>Eng. Prob. &amp; Stats</td>
<td>61</td>
<td>60</td>
</tr>
<tr>
<td>Chemistry</td>
<td>90</td>
<td>87</td>
</tr>
<tr>
<td>Computers</td>
<td>83</td>
<td>76</td>
</tr>
<tr>
<td>Ethics &amp; Bus. Practice</td>
<td>80</td>
<td>78</td>
</tr>
<tr>
<td>Eng. Economics</td>
<td>70</td>
<td>68</td>
</tr>
<tr>
<td>Eng. Mechanics</td>
<td>69</td>
<td>60</td>
</tr>
<tr>
<td>Strength of Materials</td>
<td>46</td>
<td>38</td>
</tr>
<tr>
<td>Fluid Mechanics</td>
<td>74</td>
<td>73</td>
</tr>
<tr>
<td>Material/Energy Balances</td>
<td>59</td>
<td>64</td>
</tr>
<tr>
<td>ChemE Thermodynamics</td>
<td>58</td>
<td>55</td>
</tr>
<tr>
<td>Electricity and Magnetism</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Fluid Dynamics</td>
<td>72</td>
<td>59</td>
</tr>
<tr>
<td>Heat Transfer</td>
<td>83</td>
<td>75</td>
</tr>
<tr>
<td>Mass Transfer</td>
<td>57</td>
<td>56</td>
</tr>
<tr>
<td>Chem Reaction Eng.</td>
<td>73</td>
<td>64</td>
</tr>
<tr>
<td>Process Design &amp; Econ. Opt.</td>
<td>76</td>
<td>70</td>
</tr>
<tr>
<td>Comp Usage and ChemE</td>
<td>77</td>
<td>66</td>
</tr>
<tr>
<td>Safety, Health &amp; Environment</td>
<td>75</td>
<td>73</td>
</tr>
<tr>
<td>Chemistry</td>
<td>63</td>
<td>63</td>
</tr>
</tbody>
</table>
Table 12

Areas in which UofU Chemical Engineering students performed lower than the national average.

<table>
<thead>
<tr>
<th>Subject</th>
<th>UofU % Correct</th>
<th>National Avg. % Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Properties</td>
<td>54</td>
<td>58</td>
</tr>
<tr>
<td>Engineering Thermodynamics</td>
<td>63</td>
<td>66</td>
</tr>
<tr>
<td>Process Control</td>
<td>48</td>
<td>53</td>
</tr>
<tr>
<td>Material and Energy Balances</td>
<td>59</td>
<td>64</td>
</tr>
</tbody>
</table>

Matrix for working with CLEAR

The Communication, Leadership, Ethics, and Research (CLEAR) Program (http://www.coe.utah.edu/clear/index.html) is a “collaboration between the colleges of Humanities and Engineering. The program utilizes a two pronged approach, one aspect focusing on research and faculty development, and the other emphasizing undergraduate instruction and consultation through the Center for Engineering Leadership." Chemical Engineering continues to improve our collaboration with CLEAR, particularly in years 1-3 of our program. The outline below (Table 13) lists specific courses, instructors, and activities that focus on writing, speaking, and teamwork.
### Table 13

Chemical Engineering Plan for Writing, Speaking, and Teamwork

<table>
<thead>
<tr>
<th></th>
<th>Writing</th>
<th>Speaking</th>
<th>Teamwork</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1703 (James Sutherland) | 1. Lecture on memo report: verb tense, voice, equation editing, literature referencing, and format.  
2. All homework turned in electronically.  
3. As part of selected homework problems, require one-page memo explaining solution.  
4. Require one consultation with CLEAR on one, one-page memo. |                                                                 | 1. Teamwork - lecture on benefits, organization, communication, and problem resolution.  
2. Teamwork activity focused on solving homework problems. |
| **2nd year** |                                                                 |                                                                            |                                                                          |
| 2800 (Terry Ring) | 1. Lecture on memo report: verb tense, voice, equation editing, literature referencing, and format.  
2. Require one team memo report on class project. | 1. Lecture on effective oral presentations.  
2. Team presentations on a unit process.  
Teams of three, 8 minutes per presentation, one per class. | 1. Teamwork - lecture on leadership, teamwork agreements, and problem resolution.  
2. Teamwork activity focused on presentation of unit processes. |
| **3rd year** |                                                                 |                                                                            |                                                                          |
| 3353 (Eric Eddings) | 1. Lecture on writing: voice, tense, equations, literature references, format for memo and formal reports (Geoff)  
2. Lecture on Microsoft Word: styles, captions, table of contents, figure | 1. Lecture on writing as a team (Geoff). |                                                                          |
| 3453 (Kevin Whitty) |                                                                 |                                                                            |                                                                          |
| 3853 (Geoff Silcox) |                                                                 |                                                                            |                                                                          |
lists, endnotes and cross-references (Kevin).

3. One formal report in 3353, one memo report in 3453, one memo report in 3853 with feedback from CLEAR on one memo report.

<table>
<thead>
<tr>
<th>Writing</th>
<th>Speaking</th>
<th>Teamwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4903 (Ring / Oblad, Magda / Alcoutlabi)</td>
<td>1. Lectures on memo and formal reports: verb tense, voice, literature referencing, format, and advanced features of MS Word (4903).</td>
<td>1. Lecture on organization and delivery of individual and group oral presentations (4903).</td>
</tr>
<tr>
<td></td>
<td>2. Lecture on writing and revising formal reports (4903).</td>
<td>2. Lecture on individual, contemporary issues oral (4903).</td>
</tr>
<tr>
<td></td>
<td>3. Lecture to provide feedback on reports</td>
<td>3. Lecture on technical oral presentation (4903).</td>
</tr>
<tr>
<td></td>
<td>5. Reports in 4905: 1 formal report (individual), 1 proposal (group), 1 final report (group).</td>
<td>5. Reports in 4905: 1 technical oral presentation (group)</td>
</tr>
<tr>
<td></td>
<td>6. CLEAR consultant available after first formal report in 4903.</td>
<td>6. Require informal oral quizzes before starting lab work. This will include a lab tour with</td>
</tr>
<tr>
<td></td>
<td>7. Lecture on team writing techniques.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Lecture on writing proposals.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Require two peer review memos and time for revision of first and second lab</td>
<td></td>
</tr>
</tbody>
</table>

1. Teamwork - lecture on distribution of responsibilities, follow-through, integration of individual contributions, leadership, and management issues.
Evaluation of Writing, Speaking, and Teamwork

CLEAR was deeply involved in the Projects Laboratory, CH EN 4903 and 4905, and less so in 1000- to 3000-level courses. The Projects Lab includes teamwork, oral presentations, and extensive report writing. CLEAR’s instructional activities included teaching about communication and teamwork and giving feedback on written and oral reports. The Director of CLEAR, Dr. April Kedrowicz, and the Department have developed the plan given in Table 13 for 2008-2009 to include more teamwork and communication activities in lower division courses. The following is a summary of CLEAR’s final report for Chemical Engineering for 2007-2008.

CLEAR’s involvement was minimal in 1703 (Fall 2007) and focused primarily on teamwork. They polled the students and found that about 20 percent were working together on homework assignments.

Oral Communication takes place primarily in 4903 and 4905 (Fall 2007/Spring 2008). Most of the students reported feeling a little anxiety prior to oral presentations. CLEAR focused their instruction on reducing anxiety. They also provided rehearsal sessions.

A rubric was developed for oral reports that included organization, delivery, and technical content. Students received feedback on their presentations from the CLEAR consultants and their peers. The quality of the students’ delivery styles, their use of PowerPoint, and their organization improved during the semester.
Students reported that they needed more guidance on how to work effectively in teams. Little time was devoted to this subject and some students reported that people in groups did not take responsibility for themselves.

Three class sessions in 4903 were devoted to writing lab reports. One of these provided an overview of feedback on all of the first papers and was tailored to address the problems in each section of the projects lab. One lecture was devoted to preparing memo reports and another to preparing formal reports. Sample reports for all formats are given at http://www.che.utah.edu/~geoff/writing/index.html.

The CLEAR instructors were responsible for assigning 20 percent of the grade for each report. They constructed a feedback sheet for each report. The CLEAR instructor suggested that students meet with her to go over problems in their writing, before turning in their next report. None of the students followed this advice.

The CLEAR writing instructor notes that none of our students seem familiar with the formal or the memo report format, even though the have prepared memo and formal reports in previous chemical engineering courses. The department lacks standardized formats for reports and this is confusing the students.

There were communication problems between the professors teaching the lab and the writing instructor. The writing instructor was not provided with documentation on course materials, rubrics, and assignments. This lack of information made it difficult for her to critique the students and to help them effectively.

The writing instructor feels that allotting just 20 percent of the report grade for writing tells the students that the quality of their writing is not really important. She believes that this, together with the lack of coherent writing instruction in the first three years of the program, leads the students to believe that good writing is not important. She suggests that the department consider requiring an upper-division writing course.

During Spring 2008, students in CH EN 2800 were assigned to teams of three and given the assignment of making an 8-minute presentation on a piece of process equipment. The presentations were evaluated by the CLEAR instructor and the main instructor. Overall the students took the assignment seriously and gave strong presentations that were well organized, creative, and effective at communicating technical information.

During Spring 2008, student in CH EN 4905 (Projects Lab II) were given a speaking assignment consisting of a 15-minute technical presentation on the results of one of the team experiments. Students showed improvement from the
fall semester. The talks were recorded so that students could view themselves. They also received feedback from peers and instructors.

CLEAR observed students' teamwork skills in the lab and during team oral quizzes. Three lectures were given by CLEAR and a fourth covered listening skills. At least one international student reported difficulties working with her teammates because of language and cultural differences.

Students were required to write one individual formal lab report, one team proposal, and one team formal lab report. They were also required to perform two peer reviews. The consultant conducted consultations for each student, going over feedback from the last formal report in 4903 of the previous semester. Only one student in the class took advantage of the writing instructor's offer to read through drafts before they were due. Students provided detailed feedback in the peer-review memos but the advice tended to be ignored.

Consistent feedback helped many students improve their writing and the students acknowledged their improvement in the course evaluations. The overall quality of the spring semester reports was high. The department now has consistent examples of various report formats (memo, peer review memo, formal lab report, proposal report) posted online.

The writing instructor has a number of recommendations.
1. Teaching on team writing and lab reports should begin in the first year with emphasis on formal lab reports in the second year.
2. Writing instruction in the senior year should occur primarily in Design II rather than in the projects lab.
3. The CLEAR instructors and the professors need to agree on uniform expectations for lab reports, including the use of pronouns and passive voice.
4. The CLEAR instructors and the professors need to collaborate to provide consistent feedback on assignments.
5. Professors need to impress on students the importance of effective communication of technical material to non-technical people, including the writing instructors.
6. Professors need to make students aware that if a report does not make sense to the writing instructor then the clarity of the paper is probably to blame.

**Criterion 4. Continuous Improvement**

The process of continuous improvement is shown in Figure 1. At the heart of the process are direct and indirect assessment tools. Notable among the direct evaluation tools are the FE Examination and feedback from employers of our cooperative education students. The use of these is illustrated in the previous sections on Criteria 2 and 3.
Example of Continuous Improvement Applied to Criterion 1 (Students)
There are occasionally a small number of students who cannot pass the FE Exam and who therefore cannot graduate. To help avoid this calamity, the department has raised its GPA requirements for Intermediate and Major Status from 2.3 to 2.5 and will no longer accept any grade below a C- in a chemical engineering course. This change went into effect for students entering our program in the 2008-2009 year. The date at which a student enters the program is marked by the successful processing of their application for intermediate status.

Examples of Continuous Improvement Applied to Criterion 2 (Program Educational Objectives)
In response to input from two of our constituents, our advisors from industry and the faculty in Chemical Engineering, the educational objectives were extensively revised. The new objectives emphasize graduates’ (1) success in their chosen careers, (2) social awareness, (3) engagement in lifelong learning, and (4) ethical decision making.

Responses from our alumni, along with feedback from employees of our students and graduates, show that most of our graduates are meeting the objectives.
Illustrated by Processes Used for Criterion 3 (Program Outcomes)

Our assessments by instructors, evaluations by employers of co-op students, and feedback from the CLEAR instructors suggest that some of our students are in need of better communication skills, particularly in writing. To help address this issue, the department has prepared the matrix shown in Table 13 to help coordinate communication and teamwork activities in years 1-4. In addition, and in response to input from instructors in the CLEAR Program and in Chemical Engineering, the Department has revised its Online Handbook for Writing, Speaking, and Statistics (http://www.che.utah.edu/~geoff/writing/) to include

1. more consistent examples of memo, formal, and proposal reports,
2. more consistent guidelines on making literature references, including for electronic media,
3. concise guidance on how to write a report including outlining, voice, verb tense, and equations,
4. guidance on working in teams,
5. and a concise summary on basic statistics including propagation of uncertainties and nonlinear regression.

The most recent alumni survey emphasized the importance of relating teaching to industrial practice and the importance of co-ops and internships. The alumni and the employers of interns occasionally also mention the importance of teaching students about Visual Basic Applications (VBA) - the implementation of Visual Basic that is part of Excel. The Department has responded by inviting recruiters who are visiting the U to visit some of our courses, holding an interviewing workshop, encouraging students to attend the engineering career fair and reception, and by introducing our cooperative education and internship program in our first chemical engineering course, CH EN 1703, Introduction to Computing in Chemical Engineering, and in the Undergraduate Seminar, CH EN 4753/4755. The use of VBA in solving nonlinear systems of equations was introduced in CH EN 3853, Chemical Engineering Thermodynamics, during Fall Semester 2008, by showing students how to write functions that can be called from a worksheet (see http://www.che.utah.edu/~geoff/3853/).

Illustrated by Processes Used for Criterion 5 (Curriculum)

Our distinguished lecture series gives the department the opportunity to talk to visitors from industry and other universities. Those conversations, particularly that with Lars Stromberg, suggest that there is a need for “energy engineers” who are familiar with applied thermodynamics, heat transfer, and fluid mechanics. The U of U Chemical Engineering curriculum is somewhat unusual in that it includes separate courses in engineering thermodynamics, chemical engineering thermodynamics, heat transfer, fluid mechanics, and mass transfer. That structure is consistent with a need for energy engineers and suggests that our curriculum is appropriately structured to address that need.
Illustrated by Processes Used for Criterion 7 (Facilities)
The senior exit interviews and input from the lab manager (Bob Cox) have consistently shown the need for improved laboratory facilities. Improving the lab has been a major focus of the current Chair, Professor Lighty, and lab manager, Bob Cox. The renovation efforts have included the following significant improvements.
1. Improved ventilation including cooling, the installation of canopies over equipment, and new fume hoods.
2. Renovation of our bioprocessing lab including new cabinetry, plumbing, ceiling, counters, and hood.
3. A new, energy efficient distillation column that functions and no longer exposes students to harmful vapors.
5. Consolidation of the instrumental analysis and projects labs. The two labs were formerly about 100 yards apart.
6. Reorganization of the project stations to improve safety and aesthetics.
7. Removal of unused equipment to free space for future projects.

The 2007-2008 Senior Exit interviews note that our student computing and study area (the ICC, Room MEB 2285) is frequently crowded, the computers are slow, the file structure is awkward, the login process is slow, and there are difficulties with remote access. The number of PC’s in 2285 is 36. The problem of overcrowding is being addressed by the addition of a second room containing 8 PC’s. That room, MEB 3569, currently has 8 PC’s and we are in the process of adding 8 more. Our information technology manager is testing a software tool called Vmware ACE that will allow all of the software on the ICC server to be loaded on and run from a 16 GB flash drive. This idea will give students with major status the option to purchase a flash drive that will allow them to run the department’s software on their laptops from any location with access to the internet. In addition, student computing funds are allowing the department to replace older, slower computers once every three years.

Because computing and computers are so central to chemical engineering, several instructors have been experimenting with giving exams in Lab 5 of the Cade Lab (Room WEB 210). See, for example, the exams for CH EN 3853, Chemical Engineering Thermodynamics, at http://www.che.utah.edu/~geoff/3853/. The ICC has also been used for giving exams when the class size permits.

Criterion 5. Curriculum

Overview of Curriculum in Math and Basic Science
Chemical Engineering requires two semesters of calculus (8 units), one semester of ordinary differential equations (4 units), and one semester of upper division math (at least 2 units). Our program of study recommends that students register for the Accelerated Engineering Calculus sequence, MATH 1270 and 1280. For
students who do not satisfy the prerequisites for that sequence, we accept Calculus I and II, MATH1210 and 1220, and we encourage those students to take Calculus III, MATH 2210 as a technical elective. All students are required to complete Ordinary Differential Equations and Linear Algebra, MATH 2250. At least two hours of technical elective credit in upper division math are also required. Seven math courses are approved as electives and most students choose either Applied Statistics I (MATH 3070) or Partial Differential Equations (MATH 3150).

The basic science curriculum includes two semesters of general chemistry plus labs (10 units), two semesters of physics for scientists and engineers (8 units), one semester of physics laboratory (one unit), one semester of organic chemistry plus lab (5 units), and one semester of physical chemistry (4 units). Our program of study requires that students register for General Chemistry I and II, CHEM 1210 and 1220. The general chemistry sequence includes separate labs, General Chemistry Lab I and II, CHEM 1215 and 1225. The required physics sequence is Physics for Scientists and Engineers I and II, PHYS 2210 and 2220. The associated lab is Elementary General Physics Laboratory, PHYS 1809. The single semester of required organic chemistry is CHEM 2310 and the associated lab is CHEM 2315. The single semester of required physical chemistry, covering quantum mechanics and statistical mechanics, is CHEM 3060.

Overview of University General Education Requirements and Bachelor Degree Requirements

Chemical Engineering accepts the General Education Requirements that are set by the University. These include (1) two courses in each of three subject areas: fine arts, humanities, and social sciences; (2) one course in American institutions; and (3) a Lower Division Writing requirement that is normally filled by completing Writing 2010 with a grade of C- or better.

The bachelor degree requirements include (1) an upper-division communication/writing requirement that is normally filled by completing CH EN 4905 (Projects Laboratory II), (2) a three-credit course that covers the diversity requirement, and (3) an upper-division, three-credit course that satisfies the international requirement (IR).

Chemical Engineering students can fulfill a General Education Humanities Exploration requirement and a technical elective requirement by completing PHIL 4540, Engineering, Ethics, and Society. There are three classes that will fulfill both the International Requirement and a technical elective requirement.

Overview of Engineering Topics

The engineering science and design courses are extensive and are summarized in Table 14, organized by the year and semester in the program. In addition to these required courses, students must complete 17 hours of approved technical electives. At least two of the 17 hours must be an upper division math class
taught by the math department (MATH) and at least 9 of the 17 hours must be upper division chemical engineering classes (CH EN). More information on electives is available in the Undergraduate Handbook (http://www.che.utah.edu/~geoff/FROSHGUIDE00c.pdf).

Table 14

Overview of Required Engineering Science and Design Courses for the Catalog Year 2008-2009

<table>
<thead>
<tr>
<th>FIRST YEAR</th>
<th>SPRING SEMESTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>FALL SEMESTER</td>
<td></td>
</tr>
<tr>
<td>CH EN 1703 Intro to Eng Computing (2)</td>
<td>CH EN 4755 Undergraduate Seminar (0.5)</td>
</tr>
<tr>
<td>SECOND YEAR</td>
<td></td>
</tr>
<tr>
<td>FALL SEMESTER</td>
<td></td>
</tr>
<tr>
<td>CH EN 2300 Thermodynamics I (2)</td>
<td>SPRING SEMESTER</td>
</tr>
<tr>
<td></td>
<td>CH EN 2703 Numerical Methods (2)</td>
</tr>
<tr>
<td></td>
<td>CH EN 2800 Fund. of Process Engineering (3)</td>
</tr>
<tr>
<td></td>
<td>CH EN 4755 Undergraduate Seminar (0.5)</td>
</tr>
<tr>
<td>THIRD YEAR</td>
<td></td>
</tr>
<tr>
<td>FALL SEMESTER</td>
<td></td>
</tr>
<tr>
<td>CH EN 3353 Fluid Mechanics (3)</td>
<td>SPRING SEMESTER</td>
</tr>
<tr>
<td>CH EN 3453 Heat Transfer (3)</td>
<td>CH EN 3603 Mass Transfer &amp; Separations (3)</td>
</tr>
<tr>
<td>CH EN 3853 Chemical Eng Thermo (3)</td>
<td>CH EN 3553 Chemical Reaction Eng (3)</td>
</tr>
<tr>
<td>CH EN 4753 Undergraduate Seminar (0.5)</td>
<td>CH EN 5103 Biochemical Engineering (3)</td>
</tr>
<tr>
<td>FOURTH YEAR</td>
<td></td>
</tr>
<tr>
<td>FALL SEMESTER</td>
<td></td>
</tr>
<tr>
<td>CH EN 4903 Projects Laboratory I (4)</td>
<td>SPRING SEMESTER</td>
</tr>
<tr>
<td>CH EN 4253 Process Design I (3)</td>
<td>CH EN 4905 Projects Laboratory II (3)</td>
</tr>
<tr>
<td>CH EN 4203 Process Control (3)</td>
<td>CH EN 5253 Process Design II (3)</td>
</tr>
<tr>
<td>CH EN 4753 Undergraduate Seminar (0.5)</td>
<td></td>
</tr>
</tbody>
</table>

Criterion 6. Faculty

Faculty Review under Retention, Promotion, and Tenure Guidelines

Two untenured faculty, Professors Kevin Whitty and James Sutherland, had informal reviews this year. In addition, both are up for retention in 2008-09 and SAC reports are being prepared for their teaching. Professor Eric Eddings has begun the process for promotion to Professor to be completed next year.

Five Year Tenured Reviews

All tenured faculty are reviewed every five years. Three professors were reviewed last year: Professors Jaye Magda, Mikhail Skliar, and Edward Trujillo. Their Faculty Activity Reports (FARs) note the following.

Professor Magda organized the 79th Meeting of the Society of Rheology this year with 310 international participants. The highly successful conference helped increase the visibility of our department. Dr. Magda’s goals are to complete some
publications based on the PhD work of several of his students and to advance a wireless biomedical sensor technology. He continues to teach several important classes, including the senior projects laboratory.

Professor Mikhail Skliar has recently taken on the assignment of Chair of the Graduate Program and Graduate Advisor for the department. He will continue over the next year to put effort into improving the quality of new ChE graduate students. His graduate students have recently obtained excellent jobs with industry. His goals are to keep writing proposals and publishing his students’ results.

Professor Edward Trujillo continues to include service learning in his Biochemical Engineering courses where he has students plan and demonstrate hands-on experiments related to elementary science curriculum. He is the Chair of the University Diversity Committee and the faculty advisor for the AIChE Student Chapter. This year in particular, the department co-hosted the National Student Conference with BYU. He was also involved as the 2nd VP of the National Student Chapter Committee and will be coordinating the programming for the student conference for the National Centennial Student Conference in 2008. He continues to teach the projects lab, graduate-level reaction engineering, and biochemical engineering.

**Faculty Activity Reports**

The faculty were evaluated based on their faculty activity reports (FARs) which were submitted in February 2008. Based on this information the yearly average for 13 faculty was determined for the following:

- Publications: 2.8
- Presentations: 4.7
- Instructor average based on course evaluations: 5.0
- Class average based on course evaluations: 5.0
- Number of proposals written: 4.1
- Expenditures: $320,000
- Number of graduate students: 4
- Expenditures per number of graduate students: $80,500

**Course Evaluations**

The course evaluations for 2007-2008 were reviewed to help evaluate teaching effectiveness. Each course receives an overall rating for the course and one for the instructor. Most of our instructors ranked close to or above the university average for the undergraduate and graduate courses. There were two courses from fall semester of 2007 that fell quite a bit below the university averages for the course and the instructor: CH EN 3853 Thermodynamics and CH EN 4203 Process Control. The former was being taught for the first time by a substitute instructor.


**Criterion 7. Facilities**

**Warnock Engineering Building**
The Warnock Engineering Building (WEB) opened Fall 2007 and has provide students, faculty, and staff with modern classrooms, study rooms, a tutoring center, a center for communication and teamwork (CLEAR - Communication, Leadership, Ethics, And Research), a sandwich shop, and an accessible Dean’s Office. The building has a spacious foyer that is wonderful for studying and holding social and networking events.

**CADE Lab and Testing**
The College of Engineering has several large computer labs that are open for student use and that can be reserved by faculty for giving exams. Three instructors have started to experiment with this option.

**Improvements to Projects Lab (2007-2008)**
The Department has been successful in attracting several donors who have contributed to improvements to the Projects laboratory. This has allowed us to renovate the bio-processing lab including the installation of a drop ceiling, new cabinetry, and lab benches.

Major improvements have been made in the ventilation and cooling system. The hoods have been replaced and canopies have been installed over all lab stations that emit fumes or vapors.

The improvements to specific pieces of equipment and utilities include
- Removal of the 4-story tall, bubble-cap distillation column and the long tube evaporator
- Installation of new distillation column
- Upgrading of backpressure regulators on the fuel cell
- Removal of unneeded chemicals and equipment
- Renovation of laboratory supply and storage areas
- Installation of the new ultrafiltration experiment
- On-going renovation of the absorption column including installation of new instrumentation and Opto22 control
- Remodeling of Bio-laboratory
- Replacement of Laboratory fume hoods
- Installation and upgrading of laboratory infrastructure – drain lines, power and water – as required for rearrangement of projects.

**Future Planning for Projects Laboratory**
Future plans for the Projects Lab focuses on four areas. (1) The seniors consistently remark in their exit interviews that too much of the lab equipment does not function properly. Changing that situation is the first priority of the lab instructors and department administration. (2) The Projects Lab could be more effectively used as a resource for incorporating demonstrations and simple lab
experiments in core ChE courses. The Department plans to hold a teaching retreat so that the faculty who are using the lab in their lecture courses can present what they are doing. (3) The Base Engineering Equipment Fund (BEEF) provides funding for improvements to student labs. It includes funding from the State, the University, and the Department. Future requests for BEEF funding will focus on developing a catalysis experiment and further strengthening the analytical capabilities of the lab by the purchase of one or more gas chromatographs. This will assist students in analyzing products from the catalysis experiment and various separation processes. (4) Develop a plan for the effective use of future funding from Myriad Genetics and others for the bioprocessing laboratory. Current thinking involves possible purchases of cell characterization equipment and an additional fermentation reactor.

**Expansion and Upgrading of Student Computing Facilities in Chemical Engineering**

The student computing facilities include 36 computers in the ICC (Industrial Computing Facility), 3 in the Department Library, 8 in the Starley Computing Room, and 20 remote access terminals for a total of 67. In addition, the College maintains several computing labs (the CADE labs, http://www.cade.utah.edu/) equipped with work stations, PC’s, and Mac’s. Immediate plans are to increase the number of PC’s in the Starley Room from 8 to 20.

As an alternative to remote login to the ICC, the software packages VMware ACE and VMware thinapp are being considered to give students access to our chemical engineering software, like ASPEN and FLUENT, from any computer with an internet connection. This is especially important given the growth in our enrollment.

**Criterion 8. Support**

**Development Efforts**

In the past 2 years the Department has raised $200,000 to renovate the Senior Projects Lab. The goal is to raise another $200,000.

**USTAR Faculty**

The USTAR initiative is described at http://www.ustar.utah.edu/. The following two paragraphs are taken with little change from that site.

In 2006, the Utah Legislature passed a bill that allocated $179 million to the USTAR Economic Development Initiative, $15 million in ongoing annual funding to support research teams at the University of Utah and Utah State University, $4 million to support economic outreach programs around the State and $160 million toward the construction of new research facilities at the University of Utah and Utah State.
The objective of USTAR is to bolster Utah’s research strengths and significantly increase technology commercialization to create many more high-caliber jobs throughout the state.

Prof. Marc Porter was hired under the USTAR initiative and has appointments in Chemistry and Chemical Engineering. His research interests include developing ways to rapidly screen and discover promising therapeutic compounds, nanomaterials, biomaterials, and biocatalysts.

**Criterion 9. Program Criteria**

**Demonstrate Grounding in Basic Sciences and Their Application**

The four years of our undergraduate program provide comprehensive grounding in chemistry, physics, and biology. The standard program also gives students extensive practice in applying these sciences through courses in design, projects laboratory, process control, separations, reaction engineering, thermodynamics, fluid mechanics, heat transfer, and energy and materials balances.

A basic ability to apply all of the above areas is assured by the requirement that in order to graduate in Chemical Engineering, a student must pass the general and discipline-specific sections of the Fundamentals of Engineering Examination.