# Impact of ABET EC 2002 on a Chemical Engineering Curriculum

Sean Clancey, Nam Kim,
and Gerry Caneba
Department of Chemical Engineering
Michigan Technological University

2003 ASEE Annual Conference
Nashville, Tennessee

## Introduction

Assessment of the curriculum in the Chemical Engineering Department at MTU has been ongoing since 1995. Over the following seven years, eight assessment tools have been developed and partially implemented in an effort to determine whether the curriculum meets educational objectives set forth by ABET EC2000 as well as program criteria set forth by the AIChE. These are the eight tools: (1) a department "skills test" administered to graduating seniors who volunteer to take the test; (2) internal and external reviews of plant design reports and AIChE senior design projects; (3) an exit interview of graduating seniors, conducted by the department head, regarding their views of the curriculum; (4) a survey, conducted by the College of Engineering, of alumni two and five years after graduation; (5) portfolio of written material in capstone and communications classes; (6) internal and external review of oral presentations in capstone courses; (7) student participation in the "PAWS" Safety program in the Unit Operations Laboratory; and (8) performance on the Fundamentals of Engineering exam.

Three of the tools--the departmental skills test, the interviews, and the surveys–have only been implemented since 1999. Tool five--the portfolio--has never been fully implemented, as it overlap the reviews of the plant design reports. Discussion has been conducted on folding that tool into the second tool and replacing it with a summary of the comments made by work supervisors of students completing co-op assignments. Those comments concern the supervisors' evaluation of the students' preparation for professional engineering work.

A detailed explanation of these tools can be found in the 2001 conference proceedings[1]. This paper will discuss the most recent data from these tools, then will discuss the results of curricular changes made on the basis of feedback from these tools.

## Tool #1 Skills Test

The skills test is "department designed…to be given to the students in the Spring Quarter in the Unit Operations Laboratory. The test will measure fundamental knowledge, design skills, and problem solving skills.[1]"

Prior skills test results showed a lack of readiness for the senior-level Plant Design course, with evidence showing a somewhat weak understanding of thermodynamics. Two other educational objectives were determined, relating to specific department and ABET-required outcomes: to improve student understanding of the principles of vapor-liquid equilibria and to acquire

"the ability to design a system, component, or process to meet desired needs [outcome (c)]." It was decided that the thermodynamics course should be separated into two separate three-credit courses: Classic Thermodynamics and Chemical Engineering Thermodynamics. This revision was completed in August of 2000, so the 2002 skills test should reflect improvement in the targeted areas. The skills test results were not promising. The metric for a successful performance was set at a 60% pass rate; that is, 60% of the test takers needed to score better than 70 out of 100 on the test. The 2002 results showed a mean score of 11.54 (50%) and a median score of 12.00 (52%). Only 13% answered the required 16 correct out of 23, which represents the passing grade of 70%. Table 1 gives a comparison of the results for the last three years.

Table 1
Three-year comparison of skills test results

| | **2000** | **2001** | **2002** |
|---|---|---|---|
| **Fundamentals (7/23)** | 69% | 65% | 48% |
| **Transport (10/23)** | 48% | 63% | 43% |
| **Reactor Design (3/23)** | 28% | 46% | 24% |
| **Thermo. (2/23)** | 35% | 40% | 19% |

The scores on all four portions of the exam show a significant decline from 2001, while the scores on the thermodynamic portion of the test were the lowest of all scores. But only two of the 23 questions covered thermodynamics, and one faculty member who teaches the subject argued that the questions asked did not represent the material taught in the class. We expect that in the future if the questions are more closely matched to classroom material, they should show a rise; therefore, in the spring 2003 semester, the instructor(s) responsible for the thermodynamics sequence will design the problem set for the test, and make other instructors aware of the problem set. We are unclear as to the reason for the overall decline in scores from 2001.

**Tool # 2 Analysis of Plant Design reports**
This analysis involves "plant design reports and the AIChE senior design project. Faculty not involved in teaching plant design will review these for fundamental knowledge, innovation, research, and problem-solving skills[1]."

One of the department's assessment efforts is to determine whether we are achieving ABET outcome (g), the ability to communicate effectively both orally and in writing. To address this outcome, a three-credit communication-specific course (CM 3410, Technical Communication for Chemical Engineers) was maintained in the curriculum. As an assessment measure, two plant design reports pre-selected by the department's Plant Design faculty were critiqued in 2002 by Chris Gosling of UOP. These reports were finalists for the Davis W. Hubbard award given for exceptional team performance in Plant Design . Here is a summary of the comments:

**Overall: Quality better than in previous years**

**Writing**

**Strengths:**

- **Good conclusion from data**
- **Very well-written report**
- **Good complete design info considering HS&E issues**

**Weaknesses:**

- **Lack of understanding of compositions of diesel**
- **Conclusions are weak and report is not well-written**
- **Impact of plant site and feedstock cost was not considered**
- **Bizarre ideas about effects of blending gasoline and ethanol**

In addition to keeping this course in the curriculum, another change was implemented in August, 2002, to partially address communication ability. The number of Unit Operations (UO) experiments was increased from six to eight, and instead of a full lab report students were asked to write an executive summary. The executive summary is described as a "carefully worded two-page report which should communicate results clearly and succinctly." The purpose of the changes was to address both ABET outcome (b), to design and conduct experiments as well as to analyze and interpret data, and the communication outcome. Faculty in charge of UO and Plant Design felt that the students' communication skills were improved.

**Tool #3 Exit Survey**

This tool consists of an "exit survey and exit interview of graduating seniors. The department chair will administer these in the Spring Quarter to ascertain fundamental knowledge, critical-thinking skills, and overall experience[1]."

Two curricular changes were implemented in August of 2000 to better prepare students for UO (specifically to improve readiness to perform CSTR/PDMS experiments) and Plant Design courses. Two one-credit courses (CM 3115, Measurement Analysis of Data; and CM 3315, Instrumentation Lab) taken in the junior year were integrated into one two-credit course. Also, in the past two three-credit Kinetics courses (Kinetics I, homogenous reaction systems; Kinetics II, heterogenous reaction systems) were taught senior year. Kinetics I was moved to junior year, while Kinetics II was moved up to graduate level. Faculty in charge of the unit operations lab report an improvement in ability, while the most recent grades on the CSTR experiments showed minor improvement. The experimental aptitude of students, however, was reported to be significantly improved. The exit surveys, completed by sixty graduating seniors, did not show significant improvement in perceived readiness for these courses: the score on the question concerning preparation for UO was 3.2 (on 4-point scale, with 4 being excellent) compared with 3.4 in 2001. The score on preparation for Kinetics and Reactor Design was 2.8 compared with

3.1 in 2001. More time will be needed to fully assess the results of these curricular changes.

**Tool #4 Alumni Survey**
This is a "survey of alumni two and five years out. These will be conducted by the College of Engineering and by the department. The assessment committee will evaluate the results for fundamental knowledge, communication skills, professional ethics, contemporary/global issues, and environmental/safety issues. The metric is "3.0 on a scale of 1-4 on rated questions[1]."

The results of this survey are not yet available.

**Tool #5 Analysis of Written Materials**
Tool #5 of the department's assessment plan is "Portfolio of written materials in capstone and communication courses. Faculty and an industrial group will evaluate for communication and teamwork skills." The metric is "85% pass rate (>80 out of 100 score)[1]."

This tool has never been fully implemented as it is largely an overlap of Tool 2. Discussion has been held on replacing this tool with an assessment procedure that reviews the comments about students working in co-op positions written by their supervisors. It is felt that these comments could provide a rich source of information regarding the students' preparation for workplace engineering, but no action has yet been taken on instituting this review as a formal assessment tool.

**Tool #6 Analysis of Oral Presentations**
This tool was intended to be a "Portfolio of oral presentations in capstone and communication courses. Faculty and an industrial group will evaluate for communication and teamwork skills." The metric is "80% pass rate (>70 out of 100 score)[1]." Like Tool 5, it has not been consistently implemented, and when it has been used, has been confined to capstone chemical engineering course presentations.

This year's presentations did not receive an industrial review, which is ordinarily a major part of this assessment tool. In place of those reviews, grades of oral presentations in the Unit Operations lab were recorded. A total of 60 presentations were given, and a maximum of 40 points per presentation were awarded. The results are the following:

Mean= 36.8/40 or 92%
Standard Deviation=2.1/40 or 5%

Metrics for this portion of the tool have not been established, and details of the scores are not available. We hope to have this year's presentations observed by industrial reviewers.

**Tool #7 Participation in the "PAWS" safety program**
This tool assesses"student participation in the 'PAWS' Safety Program in the Unit Operations Laboratory. A faculty committee will evaluate the level of participation to assess professional responsibility and safety

awareness." The metric is "continued improvement; > 70% of 'PAWS' forms to be generated by students not in the Safety Committee[1]."

With the department's curriculum emphasizing laboratory safety, student participation in the Unit Operations lab safety program is an important assessment tool. Following the 2001 assessment update, several recommended changes were made, which are reflected in the 2002 results. Here were the changes in the program:

(1) A safety experiment was dropped; instead, each student group was to designate a Safety Officer for each experimental cycle. The Safety Officer's duties are to do a safety inspection at the beginning of each laboratory day, coordinate the PAWS Tracking System, and conduct safety meetings.
(2) The biolaboratory should be inspected to ensure that safety corrections have been implemented.
(3) Students performing bioexperiments are to be reminded that two group members must be present when a group is assigned to be in the biolaboratory.
(4) steel-toed work boots are to be required equipment.

The results for 2002 show a very promising trend toward greater safety practices. The number of unsafe acts per student has declined since the '93-'94 school year from 1.9 to 0.6. Equipment violations per student declined from 1.1 to 0.25. The number of PAWS forms submitted, which occurs when an unsafe practice is observed, has declined from 3.0 forms per student to 0.9. It seems that the emphasis on safety is paying off in terms of greater attention to proper laboratory practices. Table 2 provides a nine-year comparison of safety practices.

Table 2
Results of PAWS Safety Program

| | 93-94 | 94-95 | 95-96 | 96-97 | 97-98 | 98-99 | 99-00 | 00-01 | 01-02 |
|---|---|---|---|---|---|---|---|---|---|
| # Studs. | 89 | 100 | 113 | 93 | 98 | 94 | 109 | 96 | 80 |
| Unsafe Acts/Stud. | 1.9 | 1.3 | 1.4 | 0.8 | 0.8 | 0.8 | 1.1 | 0.6 | 0.6 |
| Equip. Probs./Stud. | 1.1 | 0.4 | 0.3 | 0.8 | 0.7 | 0.7 | 0.9 | 0.5 | 0.25 |
| PAWS Forms/Stud. | 3.0 | 1.8 | 1.0 | 1.7 | 1.6 | 1.5 | 2.0 | 1.2 | 0.9 |

**Tool #8 performance on the "Fundamentals of Engineering" exam**

To incorporate this tool, "A faculty member who is a Professional Engineer will assess the performance for fundamental knowledge, design skills, and problem solving skills[1]."

Results for 2002 show that 30 of 36 chemical engineering majors took the test for a pass rate of 83%. This matches the performance of all chemical engineering majors in the state, and is just 6% lower than the national rate. The metric for the department's assessment purposes is a 90% pass rate. Table 3 provides the MTU, State of Michigan, and national results of the FE exam.

Table 3
Results of 2002 FE Exam

| **April, 2002 Exam** | **MTU** | **MI** | **USA** |
|---|---|---|---|
| **ChE Exam** | | | |
| Examinees | **36** | **42** | **778** |
| **Passed** | **30** | **35** | **696** |
| **% Passed** | **83** | **83** | **89** |
| **Gen'l Exam** | | | |
| Examinees | **7** | **11** | **268** |
| **Passed** | **5** | **8** | **205** |
| **% Passed** | **71** | **73** | **76** |
| **Total** | | | |
| Examinees | **43** | **53** | **1046** |
| **Passed** | **35** | **43** | **901** |
| **% Passed** | **81** | **81** | **86** |

**Conclusion**

The department is actively applying these assessment tools and is committed to using them to improve the curriculum. The specific changes most recently made, in order to better prepare students for the Unit Operations and Plant design courses, show mixed results. Grades in the targeted classes did show minor improvement, but the exit surveys did not indicate greater perceived readiness. The students' aptitude for performing experiments was reported to be improved. Results from future alumni surveys should provide more information on the effects of the changes. Emphasis on communication skills and safety appear to be paying dividends.

**References**

1. Clancey, S., Jason M. Keith, and Anton J. Pintar. "Improving the Chemical Curriculum

Through Assessment: Students, Faculty, Staff, Alumni, and Industry Input." *Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition.*

## Authors

**SEAN CLANCEY**
Sean Clancey is a Lecturer in Technical Communication at Michigan Technological University. He received his PhD
from Michigan Tech in May of 1998. Sean teaches the technical communication courses for the Dept. of Chemical Engineering. He is a member of the Association of Teachers of Technical Writing and the National Council of Teachers of English.

**NAM K. KIM**
Nam Kim is an associate professor of chemical engineering at Michigan Technological University. He was involved in the preparation of Self-Study for ABET visit. He teaches process control theory and process control laboratory courses at Michigan Tech. Kim does research in the area of advanced process control (adaptive and interacting multi-variables, statistical process control, fuzzy logic, and neural networks) and energy conservation and optimization. He has a Ph.D. from Montana State University in chemical engineering. (e-mail: kimnk@mtu.edu)

**GERARD CANEBA**
Gerry Caneba is an Associate Professor of Chemical Engineering at MTU. He received his Ph.D from the University of California at Berkeley in 1985. He discovered the free-radical retrograde-precipitation polymerization (FRRPP) process in the late 1980s. He is currently serving as a founding faculty user of the Center for Nanoscale Materials at Argonne National Laboratory in Argonne, Illinois, and he is a member of the AIChE Equipment Testing Procedure Committee (ETPC), under the subcommittee for Reverse Osmosis Systems.