Integrating Soft Criteria into the ChE Curriculum

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Abstract

Incorporating the soft criteria included in ABET 2000 into the curriculum has proved to be a challenge for many engineering programs. Our approach has been to prioritize the importance of the six criteria and proportion effort accordingly. We have been quite successful in integrating communication skills into the ChE curriculum and more than meet ABET criteria. We believe that we do a more than adequate job with our second and third priorities, teamwork and learning to learn. The current status of incorporating the fourth criterion, ethical behavior, into the curriculum is probably adequate. The final two criteria still need increased effort. Results of a survey of practicing engineers shows that laboratory and design courses and practical work experience are the most important sources for learning to satisfy the soft criteria.

I. Introduction

For many years our industrial colleagues have been telling us that several soft skills such as communication and teamwork are vitally important for the success of engineers in industry. Many engineering schools have incorporated these skills into their curricula to varying degrees.

With the advent of ABET 2000 the soft skills have assumed a greater importance. Many of these skills are incorporated in the "infamous" Criterion 3, while some are buried in Criterion 4^1 . The soft criteria listed in criterion 3 are that graduates have:

- 3d "an ability to function on multidisciplinary teams;"
- 3f "an understanding of professional and ethical responsibility;"
- 3g "an ability to communicate effectively;"

3h "the broad education necessary to understand the impact of engineering solutions in a global/societal context;"

- 3i "a recognition of the need for and an ability to engage in lifelong learning;"
- 3j "a knowledge of contemporary issues;"

Programs must assess the process "to assure that all students meet all program requirements."

Criterion 4 states that the students must be prepared for engineering practice "incorporating engineering standards and realistic constraints that include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political." Several of these items are soft criteria or have soft components. This paper discusses progress towards incorporating soft criteria into the chemical engineering program at Purdue University.

II. Background

Fortunately, many of the soft criteria do not represent new issues for engineering programs. Around twenty years ago, following the advice of our colleagues, the School of Chemical Engineering at Purdue integrated written and oral communication more tightly into the ChE curriculum. All freshmen are required to take or test out of English composition and speech courses. ChE professional development seminars for sophomores, juniors and seniors emphasize the importance of communication. Cooperative education students write reports after each work session. Many professors include written and oral project reports in technical courses.

The required senior laboratory courses and the capstone senior design course place a major emphasis on communication. Oral presentations are videotaped and critiqued individually by a communication specialist while he and the student watch the videotape. The professor or TA grades written reports for technical content and the communication specialist assesses the quality of the writing. In the first laboratory course one lecture a week is given on communication topics. To pass the course, a student must achieve an acceptable standard in communication irrespective of his or her technical performance. Employers have told us that our graduates are generally good communicators.

The first year courses were already required at the time we decided to integrate communication into the curriculum. The additional resources required a full-time communication specialist for a program with about 500 students, and an increase of one credit in the senior laboratory course. Assessment was built in as a standard part of the grading of student oral and written reports. We are happy with the results obtained for communication skills and do not want to reduce this effort. However, it is extremely doubtful if the same level of effort and resources used for communication skills can be expended for the other five soft criteria now required by ABET.

We recognized teamwork as important about ten years ago. Many of the required and elective ChE courses use group work for part of the course. These applications range from use of informal groups for lecture breaks, use of formal groups for problem solving in recitation, and use of formal groups for course projects. Senior laboratory and design courses use assigned groups for all of the projects. These grassroots efforts resulted from comments by the Industrial Advisory Committee on the importance of teams in industry and by the realization by many professors that students often learn more in cooperative teams. However, there was no formalized effort to assess the results and to help students learn how to be better performers in teams.

The faculty has always felt that the students need to learn on their own. In our laboratory and capstone design courses we purposely give students open-ended projects that require them to learn new material on their own. Over forty percent of the students take advantage of the opportunity to do independent research work under the guidance of a faculty member.

The chemical engineering faculty has always recognized the importance of professional and ethical responsibility, but, except for expecting ethical behavior, most professors do not follow up on this topic in class. A few professors have started including the discussion of expected professional and ethical behavior in their courses in the framework provided by the AIChE code of ethics. Historically, ethics was often the topic of one of the seminars in the senior seminar class.

III. New Developments

Clearly, engineering departments can successfully implement any one of the soft criteria, but it is doubtful they have the resources to do all of them at the same high level. We are prioritizing the importance of the soft criteria and allocating effort and resources accordingly. We have developed and are starting to disseminate a periodic, Internet-based survey of graduates and their employers as a summative assessment of our success in all areas of engineering education.

Our number one priority for the soft criteria remains communication skills. The advent of ABET 2000 has not changed our commitment in this area.

Our second priority is teamwork skills. Additional efforts in this area have focused on the laboratory since all projects are done in teams and there is time to focus on team interactions. The communication specialist is certified to administer the Myers-Briggs Type Indicator (MBTI)². All students take a computerized version of the MBTI either as part of the sophomore ChE seminars or as a senior. Design groups are now assigned so that groups are diverse as far as the MBTI scales are concerned, are diverse demographically, and have a spread of grade points. As much as possible, the groups are formed to balance students with preferences for Judging and Perceiving--a balance of those who are closure-oriented and those more process-oriented. The over-representation of certain personality types in engineering often makes it difficult to sort any further.

Diverse groups may have more initial conflict, but the MBTI enables them to anticipate areas of difference and provides a vocabulary for dealing with them. Most semesters the anecdotal feedback has been overwhelmingly positive. There are also modest efforts in the laboratory courses to help the students understand team interactions based on MBTI personality type. The students are given a description of the various personality types, and the possible danger areas for each type based on their least preferred function (feeling, thinking, sensing or intuition) are highlighted.

Our third priority is the importance of students being able to learn on their own, which is our interpretation of the important part of criterion 3i. We continue to assign projects that require the students to learn much of the technical material on their own. In addition, we are also focusing explicitly on the ways that different people learn. In the sophomore seminar series, students take the MBTI and in the junior seminars they take a self-scored learning styles inventory³ to better understand how they and others learn. During a discussion on learning styles we make sure that they understand the advantages of

studying in groups with a number of learning styles represented. Assessment of the ability of students to learn independently is part of the on-going discussions with the laboratory or design instructor and the final feedback on the projects.

During the senior seminar series this year the Director of Continuing Engineering Education at Purdue presented a seminar on the need for engineers to stay current through continuing education. A variety of methods to stay current in chemical engineering and to grow in other directions such as business was delineated.

Our fourth priority is criterion 3f, professional and ethical responsibility. Faculty tend to focus heavily on one narrow component of this, which is the need to emphasize ethical behavior in school to minimize cheating. The seminar series has a large number of speakers who discuss various aspects of professional responsibility. One seminar on ethics is scheduled for each of the three seminar series. Choice of the speaker is critically important for this topic since in the wrong hands the topic is deadly. The NSPE video, "Gilbane Gold," was very popular with the students and sparked further discussion. We probably need to do more on ethics such as involving the students in a simulation game such as "The Ethics Challenge."

The commitment to our fifth and sixth priorities is fairly thin. Currently, there is no broad consensus about the importance of, teaching methods for, or assessment of the last two soft criteria, 3h, a broad education to function globally and 3k, a knowledge of contemporary issues. Satisfaction of these issues will probably be allocated to the general climate at Purdue and to general education courses. The large number of international students at Purdue, particularly in engineering, makes it fairly easy for students to become aware of global issues if they make an effort. To ensure that all students meet these objectives, we will probably eschew tradition and require students to choose from a restricted list of general education courses.

We are serious about preparing students for engineering practice. Almost 40% of the graduates participate in the five-year coop program. A smaller number (31% in the 1994 survey) participate in at least one summer internship. These experiences are not required since some students plan to use a ChE degree as a background for other careers, and since it is impossible to guarantee industrial employment when the economy is down.

IV. Surveys of Graduates and Employers

To assess the ability of our graduates to compete in industry, we have surveyed our graduates at irregular intervals. Before ABET 2000 the most recent survey was done in 1994 of graduates from the 1989 to 1993 graduation classes. This survey did not specifically ask about all of the current ABET soft criteria. The advent of ABET 2000 means that surveys will become more frequent and will be expanded to include employers.

Responses to the 1994 survey indicated that 74% of the respondents took advantage of one form of work-study such as coop or internships. Forty-three percent did an independent research project. The respondents were asked to 1) rank the importance

(from a = very important to e = unimportant), 2) rank the opportunity to learn the skill as an undergraduate (from a = excellent to e = inadequate), and 3) list the sources for learning the six non-technical skills. The key for question #3 in Table 1 is: a = ChE seminar, b = ChE lab or design course, c = non-ChE courses, d = Coop or internship, and e = extracurricular activities. The percentages in the table do not add to one since varying numbers of respondents chose to omit certain questions.

The results in Table 1 for question 1 show that respondents agreed with us that communications and team interactions were the two most important soft skills. If we consider ranks a, b, and c to be passing grades, then 89% thought they had the opportunity to learn written communications, 83% thought they had the opportunity to learn team interactions as undergraduates. These numbers are gratifyingly high. The responses to engineering ethics shows that this lower priority item is not learned as well. Not only is this item considered less important, only 65% thought they had sufficient opportunity to learn about this subject in school. Thus, we clearly need to focus more attention on engineering ethics, which is one reason the number of seminars on ethics has been increased.

The sources for learning about these topics are also of interest. Although lab and design showed the highest percentages for the two communication skills, non-ChE courses, work experiences, and (for oral communication) extracurricular activities were also important. Team interactions were learned mainly in lab and design with work experiences and extracurricular activities also being important. Engineering ethics was learned mainly in the ChE seminars and work experiences. Since lab and design were meant to be the main classes where communications and teamwork were covered and ethics was concentrated in the seminars, this data confirms that they are serving these purposes. The data also show the somewhat surprising importance of work experiences for learning all of these soft skills. Extracurricular activities and lab/design are most important for practicing leadership skills, which although not one of the ABET criteria, are important for graduates who want to advance in their careers.

Our new survey, which has been developed with the aid of our Industrial Advisory Committee, covers all of the ABET criteria – technical and non-technical. The 1994 survey gives us a longitudinal basis for comparison for three of the non-technical criteria and most of the technical criteria. In addition to surveying new graduates, our new assessment process will survey their supervisors. With the help of members of our industrial advisory committee we will identify supervisors of Purdue graduates from one to five years after graduation. The supervisors will be asked about average performance levels of new hires in general and then be asked to compare Purdue graduates to that norm.

V. Comments and Closure

ABET 2000 is certainly a major step in the right direction. The new standards make engineering programs pay attention to the learning outcomes for appropriate technical and non-technical criteria. However, there are too many criteria. It is obvious that schools will have to prioritize their efforts. Compliance with the ABET criteria would be easier if the criteria were rewritten to explicitly request that schools prioritize.

We suggest that the number of criteria be reduced and made broader. Criterion 3 could be reduced to three specific items. First, programs would have to prove that students could use modern engineering, mathematics and science for the practice of engineering. Second, programs would have to prove that students could design systems subject to suitable constraints. Third, programs would have to prove that students could satisfactorily perform the non-technical roles of engineers including communication, teamwork and maintaining high ethical standards.

Bibliography

¹ "Engineering Criteria 2000: Criteria for Accrediting Programs in Engineering in the United States," *ASEE PRISM*, March 1997, 41-42.

² <<u>http://www.capt.org</u>> and <http://www.aptcentral.org>

³ Soloman, B. A. and Felder, R. M., "Index of Learning Styles," http://www2.ncsu.edu/unity/lockers/users/f/felder/public/

Biography

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Phillip C. Wankat is the Clifton L. Lovell Distinguished Professor of Chemical Engineering at Purdue University. He received a BSChE from Purdue, a Ph.D. from Princeton and a MS in Education from Purdue. He was Head of Freshman Engineering and Interim Director of Continuing Engineering Education at Purdue. He is the coauthor of the book *Teaching Engineering*.

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| | | Ranking | | | | |
|----|--|---------|----------|---------------------|-----------------|---------|
| | | а | b | с | d | e |
| 1. | Importance of: | | | | | |
| | A. Written communications. | 83 | 13 | 2 | 1 | 0 |
| | B. Oral communications. | 79 | 15 | 3 | 1 | 0 |
| | C. Engineering ethics. | 43 | 27 | 24 | 3 | 1 |
| | D. Team interactions. | 75 | 18 | 4 | 1 | 0 |
| | E. Leadership skills. | 65 | 26 | 4 | 2 | 1 |
| | F. Meeting skills. | 48 | 31 | 14 | 2 | 2 |
| Ke | ey: $a = very important to e = unimportant to e = $ | rtant. | | | | |
| | | | | | | |
| | | а | b | с | d | e |
| 2. | Opportunity to learn skill. | | | | | |
| | A. Written communications. | 17 | 46 | 26 | 6 | 4 |
| | B. Oral communications. | 17 | 38 | 28 | 11 | 4 |
| | C. Engineering ethics. | 12 | 25 | 28 | 24 | 8 |
| | D. Team interactions. | 20 | 39 | 28 | 8 | 2 |
| | E. Leadership skills. | 14 | 27 | 35 | 13 | 7 |
| | F. Meeting skills. | 7 | 20 | 33 | 20 | 17 |
| Ke | ey: $a = excellent$ to $e = inadequate$ | | | | | |
| | | 0 | h | C | d | Α |
| 3 | Sources for skills | a | U | C | u | C |
| 5. | A Written communications | 8 | 36 | 28 | 21 | 3 |
| | R Oral communications | 0 7 | 28 | 20 | $\frac{21}{28}$ | 11 |
| | C Engineering ethics | 30 | 0 | 2 4 8 | 20 | 2 2 |
| | D. Team interactions | 57 | 7 51 | 0 1 | 24 24 | 0 11 |
| | D. Tean Interactions. | 5 | 21 | 4 | 24 22 | 22 |
| | E. Leauership skills. | 5 | 31 10 | 3 | 23 4.4 | 3Z |
| | F. Meeting skills. | 0 | 19 | 3 | 44 | - 19 |

Table 1. Results of 1994 Survey of Graduates. Percent Responding

Key: a = ChE seminar, b = ChE lab or design course, c = Non-Che courses, d = Coop or Internship, and e = Extracurricular activities.