A JUNGLE GUIDE THROUGH ACCREDITATION

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We, the authors of this paper, are both involved in engineering accreditation. Each of us has taught undergraduate chemical engineering for at least twenty-five years, and each of us continues to do so. Each of us has visited chemical engineering programs by request, to evaluate whether the programs meet nationally mandated accreditation criteria. One of us (JWP) is past president of the organization that develops and applies these criteria, and the other (ELC) headed the Educational Advisory Board of the American Institute of Chemical Engineers (AIChE).

Holding these positions has made us lightning rods for criticisms of the accreditation process. No one likes to be judged, and everyone gets angry about negative judgments. We have learned that any conversation beginning "What the *#?! do you @*&!* think you're doing now?" usually introduces a reasoned comment on accreditation. Since this comment often seems personal, and since any second comment often seems exactly the opposite of the first, we and our colleagues in accreditation often end up echoing Freud's comment on his patients: "My God, what do they want?"

While individual comments are usually emotional, we believe that many have merit. This merit, however, is often obscured by individuals who complain only every six years when their own program is up for review, or who use accreditation as a convenient weapon to fend off worthwhile curriculum reforms at home. Still, we believe that common concerns run through these complaints and that the concerns are often justified.

We will explore these concerns in this paper. Our experience suggests organizing them under three headings, each of which will be discussed in the following paragraphs:

- **What should the accreditation criteria be?**
- **How are the criteria applied?**
- **How can accreditation be improved?**

WHAT SHOULD THE ACCREDITATION CRITERIA BE?

To explore this issue, the AIChE Educational Advisory Board mailed 180 questionnaires to chemical engineering professors chosen from the listing in *Chemical Engineering Faculties*. We sent questionnaires to 60 department chairs and to a roughly equal number of tenured and untenured professors. This gave every department at least one chance to respond, and large departments had more chances than small ones. Such a selection is not scientific, and untenured faculty have the annoying tendency to get promoted and ruin the distribution! Still, we got 164 responses: 51 chairs, 87 tenured non-chairs, and 26 untenured non-chairs, for a total response of 91%. About ten more sent in unmarked questionnaires with notes such as "I hate questionnaires" or "My Dean doesn't let me say anything."

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Overall Requirements • The results of this survey, summarized in Table 1, seem to reflect an overwhelming endorsement of the value of accreditation and of the existing chemical engineering curriculum. These endorsements were independent of position, *i.e.,* the responses of chairs, tenured faculty, and untenured faculty were the same. In particular, Table 1 shows that at least 86% of all respondents support the current requirements of one-half year of humanities, one year of mathematics and basic science, and one and one-half years of engineering.

Smaller majorities support the division of engineering into one year of engineering science and one-half year of engineering design. This split, which has proved to be almost impossible to judge fairly, is being reconsidered (as discussed in more detail below). Parenthetically, we note that these compelling endorsements of basic accreditation requirements are echoed by a parallel survey of engineering deans conducted by a joint task force representing ABET and the ASEE Engineering Deans' Council. On these issues, at least, chemical engineering faculty and deans agree.

Specific courses • The specific courses required for a chemical engineering degree are also endorsed by a large majority of faculty members. At least 89% support courses in basic mathematics, chemistry, and physics; 88% support a capstone course in

TABLE 1
What Should the Accreditation Criteria Be?
*(**Source:** Poll of 200 chemical engineering faculty members conducted in the fall of 1990 by the AIChE Educational Advisory Board.)*

Curricular Requirement	% Favoring Requirement
Overall requirements should include at least:	
• 0.5 year of humanities and social science	86%
• 1.0 year of mathematics and basic science	92%
• 1.5 years of engineering	87%
• 1.0 year of engineering science	70%
• 0.5 year of engineering design	62%
Basic courses should include at least:	
• Mathematics through differential equations	96%
• General chemistry	93%
• General physics	89%
• One design course`	88%
• Mass and energy balances	93%
• Fluid mechanics	94%
• Heat and mass transfer	94%
• Separation processes	88%
• Reaction engineering	93%
• One process control course	83%
• One engineering thermodynamics course	74%
• 0.5 year of advanced chemistry	63%
• One materials course	54%
• One biology course	22%

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design and one in separations; and still higher numbers endorse material on stoichiometry, transport processes, and reaction engineering. On these topics, all agree.

Not surprisingly, there is less agreement on what are often described as "emerging frontiers for chemical engineering." Slightly more than half of the respondents would require a materials course, and less than a quarter would require a course in biology. In more traditional areas, about three-quarters applaud engineering thermodynamics (we suspect that this lower percentage reflects uneasiness over possible repetition between the currently required thermodynamics courses). Sixty-three percent agree with the required one-half year of "advanced chemistry," a classification which can now include courses on microelectronics or advanced materials.

This wide agreement on the larger number of required courses means that most chemical engineering faculty support a very rigid curriculum. Quite frankly, we are dismayed that so many of our colleagues subscribe to so many requirements. To us, the best requirements would reflect *more flexibility*. Thus, we would not require specific courses in process control, materials, engineering thermodynamics, or biology for all departments, even while we might support some of these requirements for our own departments. In this sense, we urge all to think through the difference between nationally mandated criteria and those which are self-imposed at a single institution.

HOW ARE THESE CRITERIA APPLIED?

Armed with this strong consensus about what should be required, we now turn to the organizations responsible for engineering accreditation. For those who have not been involved in accreditation recently, we will briefly review the alphabet soup of acronyms involved. The key group is ABET (Accreditation Board for Engineering and Technology), a federation of some thirty-odd engineering societies. ABET is recognized by the USOE (United States Office of Education) and COPA (Council for Postsecondary Accreditation) as the only group authorized to accredit programs in engineering, engineering technology, and some engineering-related specialties within the United States and its territories. ABET gets the moral support of the engineering profession from its member societies, including AIChE. It also collects dues from them.

ABET accredits engineering programs through the EAC (Engineering Accreditation Commission), which conducts visits and votes accreditation actions for all engineering disciplines, as shown in Table 2. The AIChE interface with the EAC is the E and A Committee (Education and Accreditation Committee), a group of chemical engineers appointed by the AIChE Council. The EAC organizes accreditation visits, but the E and A Committee designates the chemical engineering visitors and exerts considerable influence on whether, and for how long, a chemical engineering program is accredited.

All of this can be confusing, especially since many call the E and A Committee the "ENA" Committee and don't understand that it's not the EAC. At one time, the E and A Committee did vote a separate accreditation on behalf of AIChE for each chemical engineering program, and ABET agreed to accept whichever action—EAC's or E and A's—was the more severe. For the past several years, chemical engineering programs have not been subjected to this kind of double jeopardy.

ABET evaluates programs against *general criteria* that apply to all fields of engineering and *program criteria* that apply only to a specific field. While both kinds of criteria must be approved by the ABET Board of Directors, the chemical engineering program criteria are recommended by the AIChE E and A Committee. This causes extra stress for chemical engineering programs in two ways:

1. Chemical engineering is the only major engineering discipline which depends heavily on chemistry. Thus chemical engineering curricula are always overcrowded by major infusions of chemistry in addition to the traditional "engineering core" based in physics. The E and A Committee has tried to ease the burden by counting other advanced sciences (*e.g.*, biology, materials science, solid-state physics) as part of the advanced chemistry requirement and by double-counting some advanced chemistry as a part of the engineering science requirement, but the extra stress remains.

2. A second source of irritation is the criticism by some ABET teams about faculty not being registered as Professional Engineers. Professional registration is much more important to disciplines such as civil and environmental engineering, whose graduates often work in private practice, than to others such as chemical and electrical engineering where most graduates work for large corporations. Edwin Layton, in his book *Revolt of the Engineers*, argues that some engineering societies are controlled by corporations who oppose professional registration as a form of unionism. In any case, registration is *not* required by the general criteria and only appears in a few program criteria, *e.g.*, those for civil and environmental engineering. No chemical engineering program can be denied accreditation or have its accreditation term reduced just because its faculty are not registered. Still, since state registration board observers often accompany ABET teams, the issue is often raised—followed by the usual round of finger-pointing and ABET-bashing.

We provide a brief summary of chemical engineering accreditation requirements in Table 3. The Official Word is given in *Criteria for Accrediting Programs in Engineering in the United States*, published

TABLE 2

Accredited Engineering Programs as of November 1991
By Program Area
(299 Schools)

Source: 1991 Annual Report, ABET Engineering Accreditation Commission

Program Area	Bachelor's Level	Masters Level	Total
Aerospace*	57	4	61
Agricultural	46	0	46
Architectural	13	0	13
Bioengineering (incl. Biomedical)	20	0	20
Ceramic	12	0	12
Chemical	145	1	146
Civil, Construction*	212	1	213
Computer	69	2	71
Electrical, Electronic*	255	3	258
Engineering (undesignated)	31	0	31
Engineering Management	2	1	3
Engineering Mechanics	9	0	9
Engineering Physics, Science	28	0	28
Environmental*	11	8	19
Forest	2	0	2
Geological, Geophysical	18	0	18
Industrial*	93	1	94
Manufacturing*	10	3	13
Materials	30	0	30
Mechanical*	234	2	236
Metallurgical	30	0	30
Mineral	3	0	3
Mining	18	0	18
Naval Architecture and Marine	12	0	12
Nuclear	25	1	26
Ocean	6	2	8
Petroleum	21	0	21
Plastics	1	0	1
Surveying	6	0	6
Systems	11	1	12
Welding	1	0	1
Other	6	0	6
Less dual titles counted twice	(5)	0	(5)
Total Accredited Programs	**1,432**	**30**	**1,462**

* Five programs within these disciplines have dual titles (*e.g.*, Aerospace and Mechanical) and are counted twice.

each year by ABET, 345 East 47th Street, New York, NY 10017-2397. The requirements are always changing, so any department facing accreditation needs a current copy.

To seek chemical engineering accreditation, a university contacts ABET, requesting evaluation and completing a self-study questionnaire describing how its program satisfies accreditation criteria. ABET, through the EAC, organizes a visit by a team that includes a chemical engineering visitor designated by the E and A Committee. The visitor compares the criteria with the university's program as described by the self-study questionnaire; interviews the chemical engineering faculty and students; and examines course materials, including samples of student work. The visitor then writes a report which is reviewed by the team chairman, an EAC editor, the EAC chairman, and at least two members of the E and A Committee before it is sent back to the school for review and comment. The E and A Committee reviews the visitor's report and the school's response and makes an accreditation recommendation; this recommendation is then presented to the EAC by one of the AIChE representatives. The EAC then takes the final accreditation action.

In spite of its Byzantine complexity, the system works. It presumes rational behavior by all concerned, and clearly, it relies especially heavily on the individual visitors. Still, the current accreditation system does have problems, and we discuss them in the next section of this paper.

HOW CAN ACCREDITATION BE IMPROVED?

We recognize that there are many complaints about accreditation, and that most people complain when they are being critically judged. Because the complaints are often vehement, we are reassured by the fact that such a wide percentage of faculty support both the general concept of accreditation and its specific requirements, as detailed above. We believe that the system for carrying out accreditation is effective, although ponderous.

TABLE 3
Brief Summary of Chemical Engineering Accreditation Requirements

I. Faculty
- A. Absolute minimum is three full-time equivalents devoted to the undergraduate program; more are required for graduate program, research, courses offered to non-chemical engineers, etc.
- B. Appropriate professional education, experience, and growth

II. Curriculum
- A. Quantitative:
  - 1.0 year of mathematics (beyond trigonometry and through differential equations) and basic science (including chemistry and physics)
  - 1.0 year of engineering science
  - 0.5 year of engineering design
  - 0.5 year of humanities and social science
  - 0.5 year of advanced chemistry (chemical engineering only)
- B. Qualitative:
  - Appropriate laboratory experience
  - Appropriate computer experience
  - Knowledge of probability and statistics
  - Competency in written and oral communication
  - Understanding of ethical, social, economic, and safety issues

III. Students
- A. Appropriate preparation for engineering study
- B. Maintain information on performance of graduates

IV. Administration
- A. Adequate support for and commitment to engineering program

V. Facilities
- A. Adequate classrooms, offices, laboratories, library, computers
- B. Functioning plan for laboratory maintenance and modernization

VI. Institutional Commitment
- A. Adequate level of financial support for program

The system seems to work best for chemical engineering—over the last five years, two-thirds of the chemical engineering programs visited received accreditation for the maximum term of six years, although some were required to submit written reports after three years to describe correction of problems observed at the time of the original visit. *This percentage of programs receiving six-year accreditation is higher than that for any other major engineering discipline.*

At the same time, we know that there are problems with the current system. We see four of these as

- **the design requirement**
- **the self-study questionnaire preparation**
- **the visitors who evaluate programs**
- **the need for educational innovation**

Each problem merits consideration and is discussed more fully in the following paragraphs.

The Design Requirement • Twenty years ago, the accreditation criteria did not include any quantitative statement on engineering design. Beginning in 1972, accredited programs were required to include at least one-half year of "design, synthesis, and systems," in addition to the existing requirement of one year of engineering science, and two years later the present requirement of one-half year of engineering design went into effect. These changes reflected a real concern that engineering faculty were becoming obsessed with mathematical analysis and were not giving students experience with open-ended problems where economic and social judgments are important. We are sympathetic to this concern.

However, a reliable evaluation of the quantitative split between engineering science and engineering design has proved to be impossible in almost every engineering discipline. One visitor commented that design is like pornography—he couldn't define either, but he knew it when he saw it!

Such a definition is not very helpful in maintaining consistency with different visitors or in planning curricular changes. Visitors have had great difficulty in judging whether a unit operations course contains 20%, 30%, or 50% design. More than one chemical engineering department has been told that its curriculum had barely enough design, but was acceptable—then six years later, a different visitor judged the same curriculum deficient in design by 5-6 semester credits. The EAC and the E and A Committee work very hard to try to make consistent judgments in a given year, but have trouble remembering what happened six years ago. It has been a mess.

As a result, the EAC has proposed combining the present engineering science and engineering design requirements into 1.5 years of "engineering topics." These must include a "meaningful, major design experience" that is developed throughout the curriculum and culminates in one or more capstone courses that integrates earlier technical work with economic, safety, and environmental constraints. For chemical engineering, this means a strong senior process design experience and the generous use of open-ended problems and projects in courses such as material and energy balances, unit operations, and chemical reaction engineering. The department must show how it meets the design requirement in its self-study questionnaire and its course materials exhibits. The key question for the visitor will be how well the curriculum develops student abilities to attack problems with more than one right answer, to communicate, to work in teams, and to understand the nontechnical contributions to engineering decisions.

We are pleased with this overdue change. It will not in any sense reduce the emphasis on design, but it *will* focus attention on the quality and rational development of the student's design experience and move us away from the unproductive bean-counting of the last eighteen years. However, the change is not yet in place. It was approved on first reading by the ABET Board of Directors in October of 1990, but will not go into effect for at least two years (to allow public comment), and so a society that wants to insist on a quantitative design requirement can propose one for its program criteria. The earliest date for final approval would be October of 1992, with the change effective for visits in the fall of 1993.

Preparation of the Self-Study Questionnaire • The accreditation procedure requires preparing a self-study questionnaire which details factors such as the economic health of the institution, the professional activities of faculty members, and the syllabi of all required courses. The completed questionnaire, in two volumes, can run to hundreds of pages. Preparation is a chore that can take as much as a year out of some unfortunate person's life. While the questionnaire contains much useful information, many complain that it is too long, too elaborate, too detailed, and too much work.

We agree. But we are unsure of how to improve the situation. Short biographies of all faculty provide important details (such as industrial and consulting experience) which go beyond existing sources like the *ACS Directory of Graduate Research*. Course descriptions and syllabi are also necessary, especially since catalog descriptions are cryptic, dated, and often unreliable. We agree that the best way to evaluate a course is to look at excellent notes, exams, homework, and sample student papers assembled by the professor in charge of the course. Unfortunately, we find that an embarrassing number of professors do not keep excellent notes, let alone exams.

Moreover, we believe that preparing the self-study questionnaire is an effective challenge for engineering deans. They may be paragons of fairness and virtue, but they are subject to major pressures that involve hard choices. These choices are usually financial and, in our opinion, are often resolved to the detriment of the chemical engineering program—this may be because chemical engineering's chemical basis is expensive and not completely understood. Preparing the questionnaire forces every dean to justify decisions to relatively impartial outside observers untarred by local politics. Still, we recognize that preparing the questionnaire is onerous work, and we welcome suggestions for making it easier.

The Accreditation Visitors • The third problem with the accreditation process is the visitors themselves, who do the on-site evaluation of how well an engineering program satisfies the ABET criteria. Such visits are not fun. They require deciphering almost inevitably tangled, incomplete questionnaires and incomprehensible student transcripts. Trying to determine course content, credit-hour distributions, and what students are *really* required to do can be difficult. Moreover, the accreditation team is under such intense time pressure that the visitor cannot even see professional colleagues and friends at the school being visited.

Most visitors do a good job. The E and A Committee works hard to insure that the visitors (known as "program evaluators" in the trade) are trained for their task; each must attend a three-hour accreditation workshop and then go on one accreditation visit as an observer before serving as an evaluator. However, even with this help a few of them still apply too rigorously the standards they think they remember from their own education, perhaps thirty years earlier . . . or disregard the criteria and inject their own educational theories into the evaluation. The E and A Committee must learn of these biases quickly and correct them in any summary report. Repeat offenders are not assigned to new visits. In addition, any school can object beforehand to an individual visitor who may have a conflict of interest or is thought to be biased. However, one school objected to 80 of 83 potential visitors, an action interpreted as an effort to predetermine the outcome of the visit.

We are indebted to those currently serving as visitors, and we are eager to encourage more who are interested. We recognize that we can offer no rewards but the feeling of service and the chance to work with other professionals in doing a job well. We admit that serving as a visitor is an invitation to criticism; every visitor who finds something lacking in a program runs the risk of vilification. At the same time, we always need good, new visitors—especially those underrepresented in our current pool. These underrepresented segments include women, minorities, and those with significant industrial experience (most of all, those with experience both in industry *and* in teaching).

If you—you, there— were critical of your last accreditation visitor, and yet (like most of us) believe that accreditation has value, why not volunteer?

Educational Innovation • Finally, we want to stress that the accreditation criteria do allow exemptions for educational innovation. We are dismayed that few departments, if any, seek accreditation on this basis. We can imagine many good reasons for such failure. One reason may be a university-wide core curriculum that restricts student choice; such curricula can cripple chemical engineering programs. Another, probably more significant, reason is the fear that deviations from a "standard" chemical engineering curriculum taught in a "standard" manner will jeopardize a program's accreditation.

The chemical engineering program criteria require coverage of certain subjects, but don't specify how much time must be devoted to each of them. If you feel that your curriculum could be improved by reducing duplicate coverage in thermodynamics and increasing student electives, why not give it a try? Why not consider replacing traditional mathematics courses with "just-in-time" modules? How about the possibility of eliminating certain required courses altogether and replacing them with student projects? If you are concerned with how these innovations affect your accreditation, discuss your goals with the E and A Committee as part of your planning.

EPILOGUE

In the final analysis, accreditation is a creature of the engineering profession, heavily influenced by engineering educators. Faculty members and deans make up the majority of the E and A Committee, the EAC, and the ABET Board of Directors. If accreditation is a problem, you and we are a big part of that problem—and you and we *must* be a big part of its solution. ❒

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