How Do You Measure Success?

Designing Effective Processes for Assessing Engineering Education
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Introduction

Frank L. Huband

If effectively implemented, the outcomes assessment process recently adopted by the Accreditation Board for Engineering and Technology will represent a substantial step forward in accreditation procedures. Rather than the traditional measuring of educational inputs such as the size of an institution's library, the number of degrees its faculty hold, and the amount of money it spends on instructional equipment, the outcomes assessment process requires that each program measure what it wants its graduates to know and be able to do—measurements much more relevant to actual learning.

Such outputs are a lot harder to define and measure, however. Because every engineering program is different, each school must establish its own criteria for success, and benchmarks for measuring these based on its own mission. It then must establish a process for evaluating and continuously improving the programs, as reflected by the benchmarks.

As an example of this challenge, one benchmark many programs may include is employer satisfaction. To be meaningful, this satisfaction level will have to be measured over a period of years—by which time the programs being assessed may have changed.

Measuring student learning is also an imprecise activity. Because each program is to assess its success based on its self-defined criteria, it will be impossible to make head-to-head comparisons among programs. One can merely conclude that an accredited program achieves a minimum level of competence and has a program in place for continuous improvement based on its self-prescribed mission and benchmarks.

Despite its implementation challenges and imprecision, the outcomes assessment process comes much closer to providing the quality assurance and accountability today's public demands, and which we should aspire to.

To help provide engineering educators with an improved understanding of how engineering programs should implement the outcomes assessment process, the American Society for Engineering Education has compiled this book of assessment articles gleaned from recent issues of ASEE PRISM magazine. We hope you find the information useful as you continue to explore how best to practice outcomes assessment.

Frank L. Huband is executive director of the American Society for Engineering Education.

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As we near the end of this century, the national mood toward higher education is shifting from demands to enlarge research and enrollment to demands to preserve and document institutional effectiveness.
—The Columbia University Accountability of Colleges and Universities, An Essay

Employers, students, parents, and funding bodies all want assurance that colleges and universities are providing quality education. Concerns over the rising cost of higher education and a shift in the skills needed to secure successful employment in the post-Industrial Age have led to a national call for assessment and accountability across higher education.

Public, governmental, and private sector attention to the effectiveness of postsecondary education is good news for the higher ed community. This increased attention acknowledges the importance of higher education to the nation and supports the growing belief that this education must change to meet new challenges.

While traditional engineering instruction has served the nation well, it is unlikely to produce engineering graduates who can respond to all of these challenges. A new instructional paradigm with new standards is needed, along with new ways of assessing those standards.

The Ins and Outs of Assessment

Most colleges and universities already have processes and procedures for internal review and assessment. Some even have offices of institutional assessment. Generally, faculty members have responsibility for the quality of their individual programs; deans and department heads monitor the performance of departmental programs; and provosts and presidents oversee the quality of the institution as a whole. How well these parties implement this internal assessment, and how well that assessment process encourages innovation and improves the quality of the educational program, varies widely from institution to institution.

What is certain is that internal or institutional assessment by itself does little to convince the public of an institution’s ability to provide quality education. For this purpose, external accountability or accreditation can be of the greatest help to the institution. It can inform the general public as well as those within the profession that the program meets the standards of the profession.

ABET Accreditation: National Accountability for Engineering Education

The Accreditation Board for Engineering and Technology, Inc., a federation of 28 engineering technical and professional societies, is recognized as the sole agency responsible for the accreditation of U.S. educational programs that lead to engineering degrees.

Since its beginnings as the Engineers’ Council for Professional Development nearly 65 years ago, ABET’s official philosophy has been to encourage innova-
tion in engineering education. Unfortunately, ABET began to drift away from this philosophy after World War II, as new engineering programs, and hence accreditation workloads, rose rapidly. ABET evaluators became more dependent on rules and criteria, finding it easier and less time-consuming to evaluate a program’s compliance to these than to evaluate innovative curriculum responses to a changing world. In fact, during this period, accreditation criteria grew from a few paragraphs to 30 pages of detailed course descriptions, credit-hour requirements, mandated numbers of faculty members, and so on.

Within the last decade, however, government and industry leaders as well as forward-thinking educators have increasingly called on ABET to lessen its preoccupation with quantitative criteria and respond to the fundamental challenges facing engineering education in the 21st century.

ABET first reacted with modest changes to the accreditation process. Notable among these were new engineering design criteria, which moved away from the rigid 16-credit hours requirement for engineering design, and the Innovation Clause (section II.A.7), which allowed institutions to submit innovative programs that did not satisfy the quantitative aspects of the criteria but met the spirit and intent of the criteria.

Broader reform was called for, however, so in 1992 ABET invited leaders from industry, academe, and the engineering professional societies to participate in the Accreditation Process Review Committee (APRC). ABET asked the committee to help outline “a quality-oriented, flexible accreditation system that encourages diversity and does not inhibit innovations in engineering education.”

The APC identified three key issues it believed must be resolved in order for ABET to achieve its prescribed goal. These issues were

- the excessive length and specificity of the accreditation criteria;
- the difficulty in attracting mid-career professionals from industry and research universities to participate as leaders in the accreditation process; and
- the complexity and length of the accreditation process.

The APC concluded that successful resolution of these issues would require joint action and consensus among all stakeholders in engineering accreditation. So in 1994, with support from the National Science Foundation and industry, ABET convened three consensus-building workshops of representatives of the engineering professional societies, research and undergraduate engineering education institutions, and engineers in industry and private practice. Each workshop focused on one of the three key issues the APC identified: criteria reform, broadened participation, and process reform.

Enter ABET’s Engineering Criteria 2000

Workshop participants submitted lists of recommendations, which eventually became the basis of Engineering Criteria 2000, a radically new set of criteria for accreditation of U.S. engineering programs.

After a one-year comment period, the ABET Board of Directors approved the criteria on November 2, 1996, and at the same time, authorized a two-year pilot study and three-year phased implementation period, making the new cri-
Chapter 1—Assessment Criteria

Engineering Criteria 2000 is composed of eight criteria that emphasize quality and professional preparation. The document maintains the traditional core of engineering, math, and science requirements, but also places importance on a new skill set that includes teamwork as well as global, economic, social, and environmental awareness.

At the core of Engineering Criteria 2000 is an outcomes assessment component that requires each engineering program seeking accreditation or reaccreditation to establish its own internal assessment process, which in turn, will be assessed by ABET. The outcomes assessment component calls for:

- detailed, published educational objectives that are consistent with the institution’s mission and Engineering Criteria 2000;
- a curriculum and process that ensures the achievement of these objectives; and
- a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

This component provides flexibility for major innovations in curricular design and delivery methods, while assuring quality engineering education.

For programs whose faculty and administration envision no immediate programmatic innovations, the outcomes assessment portion of Engineering Criteria 2000 is a useful self-test to determine if the programs’ traditional goals are being met on a consistent basis. (See the following page for answers to frequently asked questions about the outcomes component of Engineering Criteria 2000.)

**A Worthwhile Effort**

No one expects that the outcomes assessment component of Engineering Criteria 2000 will be easy to implement. Establishing measurable objectives and evaluating their outcomes are sophisticated activities with which most engineering educators have had little or no experience. ABET, along with the National Science Foundation and industry leaders, is sponsoring a massive educational effort to develop knowledgeable program evaluators and team chairs as well as engineering deans, department heads, and key faculty members who can participate effectively in the new accreditation process. Workshops and pilot tests are underway, but a major, continuous effort will be needed.

Although adapting to the new accreditation process will require much work, it will be well worth the effort. Technology has prompted most of the changes our society has witnessed in recent decades, and it will play an even larger role in the future. Engineering therefore will drive many of the transformations of the 21st century. The engineering education accreditation process must promote the innovation and continuous improvement necessary to prepare graduating engineers for these exciting opportunities.
Frequently Asked Questions About Engineering Criteria 2000

1. How can I get a copy of Engineering Criteria 2000?

A copy of the general criteria is included in this book (pp. 13–16). You can access the complete criteria, including the discipline-specific criteria, from the ABET Web site at www.abet.org.

2. When do the criteria go into effect?

Beginning in the academic year 2001–2002, all engineering programs will be required to show that they satisfy Engineering Criteria 2000 when they apply for or renew their accreditation. In the meantime (1998-99 through 2000-01), institutions may elect to have their programs evaluated under the current criteria or under Engineering Criteria 2000.

3. Our engineering school is scheduled for an accreditation visit in 1999, one of the years when institutions have an option of using either the new or old criteria. Can some of our programs go under the old criteria and some under the new?

No. If an institution elects to be reviewed under Engineering Criteria 2000, all of its programs must be reviewed under the new criteria. Because the new criteria require a large institutional mind-set change, ABET believes that to be most effective an entire engineering school, not just piecemeal programs, must make a commitment to change.

4. If our engineering program receives accreditation under the old criteria in 1999, will the accreditation be valid for the usual six years, even though the new criteria will become mandatory in the year 2001?

Yes, the accreditation will still be valid for six years. ABET knows programs are continually evolving and will expect that the schools are taking steps to prepare for the new criteria.

5. Engineering Criteria 2000 specifies that each engineering program must establish objectives and that the program's curriculum must assure the achievement of these objectives. How should an engineering program create these objectives? Should it just adopt the 11 objectives for engineering graduates listed under Criterion 3 of Engineering Criteria 2000?

A program should create educational objectives that are consistent with the mission of the institution and Engineering Criteria 2000. Ultimately, these educational objectives encompass the program outcomes listed in Engineering Criteria 2000, but ABET expects that most schools will go well beyond merely adopting the listed outcomes. Once a program has established its objectives and desired outcomes, it can make meaningful, innovative curriculum changes and strive for continuous improvement.

6. Engineering Criteria 2000 also specifies that each engineering program must have an assessment process. What does this mean and what is the purpose of this?

Thomas Angelo, former director of Assessment Forum of the American
Association for Higher Education (AAHE), defines assessment as “an ongoing process aimed at understanding and improving student learning. It involves making expectations explicit and public; setting appropriate criteria and high standards for learning quality; systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards; and using the resulting information to document, explain, and improve performance.”

To receive ABET accreditation, each engineering program must have an assessment process with documented results that demonstrate: 1) that the outcomes important to the institution’s mission and the program objectives are being measured, and that the program is achieving the desired outcomes and 2) that the results are being used to improve the program. Beyond ABET accreditation, the assessment process offers each program a means of close scrutiny aimed at self-improvement.

7. Where can we get help in conducting program assessment?

You may want to contact your university’s education school—if it has one—to seek the help of faculty members or graduate students specializing in assessment. Other useful contacts include representatives from other academic programs that have performed outcomes-based assessment, perhaps for regional accreditation or specialty accreditation.

There are also many useful journals and books on assessment. Among these are the works of the Assessment Forum of the American Association of Higher Education, which can be ordered by calling, (202) 293-6440, ext. 11. The ABET Web site, www.abet.ba.md.us, also includes information on outcomes assessment and features a bibliography of assessment publications.

8. Which assessment methods does ABET recommend using?

There are many valid assessment methods including, but not limited to, student portfolios, nationally normed subject-content examinations, alumni surveys that document professional accomplishments and career development activities, employer surveys, and placement data of graduates. It’s up to each engineering program to select the assessment methods that it deems most appropriate to the outcome being assessed.

One assessment method alone, however, is generally insufficient to measure a desired outcome. Some assessment experts recommend using as many as three methods to measure a desired outcome.

9. Will ABET evaluators, who are used to ABET’s old bean-counting accreditation mentality, be prepared to apply the new, more flexible criteria?

ABET conducted a one-day work session in January 1997 to address how best to train ABET evaluators as well as engineering faculty in the new accreditation process. Using recommendations from the participants, who represented more than 90 percent of all currently accredited engineering programs, ABET developed a comprehensive, three-phase training framework. The first phase of the framework provided sessions to train ABET trainers. It was con-
ducted in spring 1997 in conjunction with phase II of the pilot study. The second phase of the training provided program evaluator training throughout fall 1997. ABET is seeking additional funding to support the third phase, which will provide training for deans, program heads, and faculty. All training is designed to cover the process and conduct of an accreditation visit under Engineering Criteria 2000 and to provide information on such topics as outcomes assessment and continuous program improvement.

10. Five engineering schools recently underwent the accreditation process using Engineering Criteria 2000 on an experimental basis. What did ABET learn about from this experiment?

The pilot study was very successful. The results provided useful information that allowed ABET to revise its self-study questionnaire and onsite visit procedures. This information also is providing the basis for case studies that will be published on the ABET Web site and in new training materials designed for program evaluators and team chairs.

George D. Peterson is executive director of the Accreditation Board for Engineering and Technology.
U.S. engineers are experts at adaptation. They moved with ease from the hallmark public works efforts of the pre-World War II era through the explosive growth in aviation, transportation, electronics, and communication of the post-World War II era. Today engineers are mastering the global marketplace, where business driven by engineering expertise gives the United States its competitive edge.

Take a close look at the multinational engineering firms building the roads, bridges, and water treatment plants across the unindustrialized sectors of the globe, and you will see the impact of U.S. engineering. That impact is an integral component of all manufactured products, from heavy equipment and durable goods to consumer items. And telecommunication and satellite systems and massive computer networks linking world financial markets are all developed, maintained, and improved upon by U.S. engineers.

Engineering educators can look upon these accomplishments with pride. At the same time, however, these accomplishments set a high standard and challenge us to ensure that engineering education will continue to produce such high-quality professionals.

Adding to this challenge is the call by industry leaders for new qualities in engineering graduates. Engineers who can work in teams, perhaps with team members in other countries, and who are familiar with quality improvement and customer focus concepts. They want engineers who are aware of and can work in engineering's new social and environmental contexts. Finally, industry knows that the engineers of the next century must be able to handle a rapidly evolving workplace where lifelong learning is essential to keeping up with the field's evolution.

Meeting these new demands requires nothing less than a paradigm shift in engineering education. Academic leaders have already taken action toward that goal. On November 2, 1996, the Board of Directors of the Accreditation Board for Engineering and Technology approved Engineering Criteria 2000, Criteria for Accrediting Programs in Engineering in the United States.

Engineering Criteria 2000 raises those standards to meet the engineering education needs of the 21st century.

ABET, a federation of 28 engineering disciplines and professional societies representing 1.8 million engineers, developed Engineering Criteria 2000 with advice and input from industry and academic leadership and with support from corporate sponsors and the National Science Foundation.

The document (see pp. 13–16) is a simplified, flexible set of outcomes-based criteria that will stimulate positive program innovation in curricular de-
sign and delivery methods while supporting a diverse spectrum of engineering program missions and goals.

Engineering Criteria 2000 encourages programs to clearly state their academic goals and the process by which those goals are to be reached. ABET accreditation will provide a periodic evaluation to ensure that these goals are being met, and that the program remains effective.

While Engineering Criteria 2000 reflects concepts of change from the corporate culture, it also retains its own strong, professional base in mathematics and engineering science.

In approving Engineering Criteria 2000, ABET formally ushers in a new era of engineering education and provides the nation with a commitment for retaining its competitive edge. Engineering Criteria 2000 is another proud example of the quality and adaptability of U.S. engineering.

Winfred M. Phillips is the engineering dean at the University of Florida. He is a past president of both the American Society for Engineering Education and the Accreditation Board for Engineering and Technology.
The Accreditation Board for Engineering and Technology (ABET) is recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering. The first statement of the Engineers' Council for Professional Development (ECPD, now ABET) relating to accreditation of engineering educational programs was proposed by the Committee on Engineering Schools and approved by the council in 1933. The original statement with subsequent amendments was the basis for accreditation until 2000. The statement presented here is required of programs beginning in 2001.

Programs may be accredited at the basic or the advanced level. However, a program may be accredited at only one level in a particular curriculum at a particular institution. All accredited engineering programs must include “engineering” in the program title.* To be considered for accreditation, engineering programs must be designed to prepare graduates for the practice of engineering at a professional level.

(*An exception has been granted for programs accredited prior to 1984 under the title of Naval Architecture.)

I. Objectives of Accreditation

The ABET accreditation process is a voluntary system of accreditation that
1. assures that graduates of an accredited program are adequately prepared to enter and continue the practice of engineering;
2. stimulates the improvement of engineering education;
3. encourages new and innovative approaches to engineering education; and

4. identifies these programs to the public.

II. Basic–Level Accreditation Criteria

It is the responsibility of the institution seeking accreditation of an engineering program to demonstrate clearly that the program meets the following criteria.

Criterion 1. Students

An important consideration in the evaluation of an engineering program is the quality and performance of the students and graduates. The institution must evaluate, advise, and monitor students to determine its success in meeting program objectives.

Criterion 2. Program Educational Objectives

Each engineering program for which an institution seeks accreditation or reaccreditation must have in place:

a) detailed, published educational objectives that are consistent
with the mission of the institution and these criteria;  
b) a process based on the needs of the program's various constituencies in which the objectives are determined and periodically evaluated;  
c) a curriculum and process that ensures the achievement of these objectives; and  
d) a system of ongoing evaluation that demonstrates achievement of these objectives and uses the results to improve the effectiveness of the program.

Criterion 3. Program Outcomes and Assessment  
Each program must have an assessment process with documented results. Evidence must be given that the results are applied to the further development and improvement of the program. The assessment process must demonstrate that the outcomes important to the mission of the institution and the objectives of the program are being measured. Evidence that may be used includes, but is not limited to, the following: student portfolios, including design projects; nationally normed subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates.

Engineering programs must demonstrate that their graduates have:  
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;  
d) an ability to function on multidisciplinary 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/societal context;  
i) a recognition of the need for and an ability to engage in lifelong learning;  
j) a knowledge of contemporary issues; and,  
k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The institution must have and enforce policies for the acceptance of transfer students and for the validation of credit for courses taken elsewhere. The institution must also have and enforce procedures to assure that all students meet all program requirements.

Criterion 4. Professional Component  
The Professional Component requirements specify subject areas appropriate to engineering, but do not prescribe specific courses. The engineering faculty must assure that the curriculum devotes adequate attention and time to each component, consistent with the objectives of the program and institution. The curriculum must prepare students for engineering practice culminating in a
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Engineering Criteria 2000

major design experience based on the knowledge and skills acquired in earlier coursework and incorporating engineering standards and realistic constraints that include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political. The professional component must include:

a) one year of college-level mathematics and basic sciences (some with experimental experience) appropriate to the discipline;

b) one and one-half years of engineering topics, to include engineering sciences and engineering design appropriate to the student’s field of study; and,

c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

Criterion 5. Faculty

The heart of any educational program is the faculty. The faculty must be of sufficient number, and must have the competencies to cover all of the curricular areas of the program. There must be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners as well as employers of students.

The faculty must have sufficient qualifications and must ensure the proper guidance of the program, its evaluation and development. The overall competence may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching experience, ability to communicate, enthusiasm for developing more effective programs, level of scholarship, participation in professional societies, and registration as professional engineers.

Criterion 6. Facilities

Classrooms, laboratories, and associated equipment must be adequate to accomplish the program objectives and provide an atmosphere conducive to learning. Appropriate facilities must be available to foster faculty-student interaction and to create a climate that encourages professional development and professional activities. Programs must provide opportunities for students to learn the use of modern engineering tools. Computing and information infrastructures must be in place to support the scholarly activities of the students and faculty and the educational objectives of the institution.

Criterion 7. Institutional Support and Financial Resources

Institutional support, financial resources, and constructive leadership must be adequate to assure the quality and continuity of the engineering program. Resources must be sufficient to attract, retain, and provide for the continued professional development of a well-qualified faculty. Resources also must be sufficient to acquire, maintain, and operate facilities and equipment appropriate for the engineering program. In addition, support personnel and institutional services must be adequate to meet program needs.
Criterion 8. Program Criteria

Each program must satisfy applicable program criteria. Program criteria provide the specificity needed for interpretation of the basic level criteria as applicable to a given discipline. Requirements stipulated in the program criteria are limited to the areas of curricular topics and faculty qualifications. If a program, by virtue of its title, becomes subject to two or more sets of program criteria, then that program must satisfy each set of program criteria, understanding that overlapping requirements need to be satisfied only once.

III. General Advanced-Level Programs

Criteria for advanced-level programs are the same as for basic-level programs with the following additions—one year of study beyond the basic level and an engineering project or research activity resulting in a report that demonstrates both mastery of the subject matter and a high level of communication skills.
In 1996, the Joint Task Force on Engineering Education Assessment issued a report on program assessment that today is considered a valuable guide for contemplating an assessment framework. Following is an excerpt from the report.

Program assessment, properly implemented, can be a means for increasing our understanding of engineering education and for improving it. With a common appreciation of the purpose and value of assessment, the engineering community can conduct a much-needed dialogue that will lead to the identification of those capabilities likely to be needed by engineering graduates throughout their professional careers, and of the ways to best develop those capabilities.

Undergraduate engineering education must be a foundation for lifelong learning. As such, it has an obligation, especially to those expecting to enter a profession, to educate broadly in the tradition of a liberal education. It creates a base for further study, for the potential to perform as a reflective practitioner, and for the assumption of the leadership roles needed to advance the profession. In light of these factors, the assessment of engineering education is a significant concern of the engineering community and the profession.

One comprehensive view of the nature and purpose of assessment of higher education programs is given by Thomas Angelo, former director of the Assessment Forum for the American Association for Higher Education (AAHE), in “Reassessing (and Defining) Assessment,” (AAHE Bulletin, November 1995) as follows:

Assessment is an ongoing process aimed at understanding and improving student learning. It involves making our expectations explicit and public; setting appropriate criteria and high standards for learning quality; systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards; and using the resulting information to document, explain, and improve performance. When it is embedded effectively within larger institutional systems, assessment can help us focus our collective attention, examine our assumptions, and create a shared academic culture dedicated to assuring and improving the quality of higher education.

Recognizing the importance of assessing engineering education programs, the major “stakeholders” of the engineering education enterprise in the United States formed the Joint Task Force on Engineering Education Assessment in 1994. The task force consists of two representatives each from the Accreditation Board for Engineering and Technology, ASEE, the Engineering Deans Council (EDC), the National Council of Examiners for Engineering and Surveying (NCEES), and the National Society of Professional Engineers (NSPE). The task force’s objective is . . .
To review the current status of higher education assessment activities and propose a comprehensive process that will eventually lead to the development and acceptance by key stakeholders of a framework for a spectrum of activities appropriate to the engineering education enterprise and to the individual missions of engineering colleges.

Within the context of this objective, the task force has developed a report that is divided into the following five sections:

- an introduction to the task force members’ common agreement on the values of assessment
- current assessment practices and directions
- guidelines for designing an assessment framework for engineering education programs
- examples of assessment measures available to the engineering education community
- assessment ideals.

Following is an excerpt from the third and fourth sections of the report.

**Guidelines for Designing an Assessment Framework**

The design of an assessment program for any degree-granting engineering unit is a critical step in the overall assessment process and requires careful consideration of the following factors:

**Institution-Specific Mission and Goals**

An assessment program must be developed in the context of the distinct mission of each engineering program. While focusing specifically on curricular concerns that relate to the educational goals of the academic unit, the program should in no way deter, and in fact should help to synergistically promote, other valid purposes. For example, a research-active institution should seek to advantageously integrate research programs into both the classroom and the experiential components of the undergraduate curriculum. Universities with a strong commitment to external service should design courses that relate the academic experience of the student to that service function. Engineering programs developed in the context of a strong liberal arts college should provide high-quality, broad-based humanities and social science offerings. In each of these cases, an assessment program should be capable of recognizing and reinforcing the individual mission of each school and should thereby encourage the diversity of educational goals, which reflects one of the strengths of engineering education in the United States.

**Institution-Wide, Longitudinal Assessment Programs**

The assessment of engineering programs is best accomplished not as an isolated undertaking but in concert with a coordinated institution-wide effort at program improvement. This allows the assessment to be done on a comparative basis with other programs within the institution and enables judgment of the substance and depth of engineering programs in the light of the broader-based general education objectives of the school. As program improvement is
the objective of assessment, schools are cautioned to assure that assessment results are measuring the consequences of a program characteristic that has operated for a sufficiently long period of time to provide a causal relationship to the outcomes being measured. Program modifications over relatively short intervals are likely to make assessment impossible.

**ABET Accreditation**

The most widely recognized form of engineering program assessment in the United States is the periodic accreditation review conducted by ABET. The task force strongly encourages use of the ABET Engineering Criteria 2000 in developing criteria for engineering education program assessment. The entire engineering community will need to play a stronger role in relating outcomes measures to professional practice, career achievement, and civic contribution.

**Beyond ABET: Broader Career Goals**

Engineering program assessment should recognize the pitfalls of overspecialization in the face of an increasing demand for graduates who can demonstrate adaptability to rapidly changing technologies and to increasingly complex multinational markets. Assessment measures should be sufficiently broad to encompass the educational benefits of an engineering program for students preparing for careers in medicine, finance, law, business entrepreneurship, and other areas. Specific measures of student performance should relate to this increasingly recognized wider range of career opportunities.

**Cost Factors**

The cost of any assessment program should be clearly outweighed by the benefits to the educational programs under review. Although administrative personnel who design an assessment program must receive adequate resources to enable its completion, the extent of expenditures should not have a negative effect on the educational program itself. In the interest of economy, it is vital that assessment and accreditation efforts be well integrated. This assures efficiency in program evaluation and consistency in objectives defined to be common to all engineering programs. On a broader scale, it is economically advantageous to view engineering as a single, overlapping continuum that includes the educational process, assessment, accreditation, licensure, professional practice, and constructive citizenship. From this viewpoint, costs associated with an assessment program are more readily accepted.

**Examples of Program Assessment Measures**

There is a diversity of both educational objectives and the means by which we measure the attainment of these objectives. Some of these objectives are more narrowly defined, such as the mastery of a particular skill or method, while others, such as understanding the impact of engineering solutions in a societal context or the ability to design, are more broadly construed. Clearly, no one assessment device will suffice for all the educational objectives that we
expect the modern engineering graduate to obtain from today's university education. This need for an array of devices prompted the task force to develop a matrix of measures from which to choose (see pp. 24 and 25).

Further reinforcing the need for a matrix of choices was Thomas Angelo's advice to the task force that one assessment device is generally insufficient to measure a desired outcome. Angelo suggested choosing as many as three different measuring devices. In this manner, using a phrase familiar to engineering measurement, a “triangulation” could be performed on a particular outcome.

It is important for all members of the engineering community to recognize the need for purposeful experimentation in validating a set of measures for assessing an engineering education program. For example, the Fundamentals of Engineering (FE) examination, for use by the state engineering registration boards, is under revision by NCEES so that it might better serve as an assessment tool. Some schools have adopted the examination as a program assessment measure, even though a great many students have shown little interest in achieving engineer-intern status, and thus little interest in passing the examination. Many of these students have been given little or no advice about the licensing process. This lack of connection between the test as a program assessment

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**Attributes of an Engineer**

The Accreditation Board for Engineering and Technology, whose periodic accreditation review is the most widely recognized form of program assessment in engineering education, requires programs to satisfy the ABET Engineering Criteria 2000. According to the criteria, engineering graduates must demonstrate the following attributes:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs
- an ability to function on multidisciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global/societal context
- a recognition of the need for and an ability to engage in lifelong learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
measure and student desire to become licensed has resulted in schools finding some students doing no more than signing the FE examination score sheet and leaving the examination site. Further complicating the use of the exam as a program assessment tool is the fact that ASEE’s Engineering Deans Council, at its 1994 Annual Meeting, voted unanimously to reaffirm that “... graduates of ABET-accredited programs should be considered engineers in training and deemed to have passed the FE exam.”

Most, if not all, measures available are limited in their ability to assess program quality. Measures of student outcomes in the absence of information about the students entering a program will not reflect the impact of the program on students as well as a system of evaluation measures that can account for students’ development since entering the program. Also, validating the relationships of measures to actual professional performance will require several yet-to-be established longitudinal studies of significant scope. Until the results of these studies are available, actions taken to improve programs on the basis of such measurements would be both premature and ill- advised. Several post-graduation devices that might relate to the stated objectives of a school’s mission are included in the matrix as a set of possible corollaries available to validate program assessment measures over time. It is in the post-graduation performance of graduates that measures are most in need of articulation. The task force calls on the broader engineering education community to focus its attention on this need.

A matrix of possible program assessment measures is presented as a starting point to foster discussion among all constituents interested in engineering education. Where there is a likely intersection between an educational objective and its measuring device, the task force has attempted to insert an estimate of correlation: 1) for those techniques perceived by the task force to be reasonably correlated, 2) for moderately correlated, and 3) for possibly correlated. The matrix is intended to convey the need for sufficient breadth to measure most attributes (objectives) with three or more measurement devices. This matrix recognizes the need to validate the relationship of a specific criterion— or desired educational outcome— with both its measurement and its subsequent validation in the form of professional and personal accomplishments.

The rows of the matrix show attributes desired of a graduate. They fall into three broad categories:

- attributes of an engineer as defined in the ABET Engineering Criteria 2000
- special attributes particular to the objectives of the university
- nonengineering practice professional goals.

The first set of attributes, taken from ABET Engineering Criteria 2000, is listed in the sidebar on page 20. The second set incorporates specific campus and departmental goals. These goals include civic and organizational leadership skills that are developed within specific school missions such as those of the military academies (leadership), colleges with religious affiliations (community service), and schools that emphasize integrated liberal arts knowledge. The third set represents the broad abilities obtained by an engineering student and can include admission into professional schools of other disciplines such as...
as law and medicine, entry into advanced engineering education, or even embarking on industrial and managerial careers of a nonengineering nature.

The columns of the matrix include candidate assessment devices to which others can be added. They are loosely grouped by measurement of pre-graduation and post-graduation indicators.

**Pre-Graduation Indicators.** These indicators can include transcript data (courses attempted by students and corresponding grades) as well as levels of attainment on a “major field assessment test” (MFAT) such as the FE. Pre-graduation indicators can also include grades on the Graduate Record Examination (GRE) and on the following professional school entrance examinations: Graduate Management Admissions Test (GMAT), Law School Admissions Test (LSAT), and the Medical College Admissions Test (MCAT). Non-numerical measures can include portfolios of student work, video recordings of the students presenting examples of their work, and co-curricular resumes (e.g., a transcript listing extracurricular activities such as honor society membership or community service participation). A portfolio can be simply described as a packet of materials and documents collected to demonstrate a student’s competence and skills. A student portfolio might contain the best examples of experimental inquiry conducted during the undergraduate years, an original design report, writing samples, and so on. As such, portfolios can be sampled to assess the overall learning that takes place in a program. Similarly, videotapes can capture the levels of student accomplishment in oral communications or effective teamwork.

**Post-Graduation Achievements.** Post-graduation achievements include monitoring the movement of graduates into graduate and professional schools, determining the flow of graduates into careers, counting the number of job offers per graduate, and recording average starting salaries. Institutions can also conduct five-year and 10-year post-graduation career surveys and can survey students at some time after graduation for a more disinterested self-evaluation of their educations.

The task force encourages all members of the engineering community to identify indicators and measures that would help to evaluate programs and specific educational objectives, and to articulate the nature and extent of the attributes appropriate to each engineering discipline. Again, each discipline should establish as clear a linkage as possible between each proposed measure of program assessment and subsequent professional performance.

There is much yet to be done if program assessment is to reach its full potential to improve engineering education. Expanding the listing of potential indicators is a first step. How these measures are to be interpreted is an art in early development, and the task force cautions the engineering community to recognize it as such.
Task Force Members

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Kenneth A. McCollom, Oklahoma State University
Paul R. Munger, University of Missouri-Rolla

National Society of Professional Engineers (NSPE)
Donald M. Edwards, University of Nebraska
Calvin E. Weber, Retired

ASEE Secretariat
Cary Fisher, Past-President (Invited Task Force Participant)
Frank Huband, Executive Director
Ann Leigh Speicher, Manager, Office of Public Affairs
Tracy Lawless, Public Affairs Associate
Matrix of Engineering Education Assessment Measures

Pre-Graduation Devices

<table>
<thead>
<tr>
<th>Desired Attribute</th>
<th>Test</th>
<th>GRE</th>
<th>LSAT</th>
<th>MCAT</th>
<th>GMAT</th>
<th>Self-Assessment</th>
<th>Portfolio</th>
<th>Video</th>
<th>Presentation</th>
<th>Co-curricular</th>
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Campus and Departmental Goals

| Integrated Liberal Arts                                      | 1    | 3   | 2    | 1    | 1    | 1               | 2         |       |              |              |       |
| Leadership and Global Awareness                              | 2    | 2   | 2    | 2    |      | 1               |           |       |              |              |       |
| Community Service                                            | 2    |     | 1    | 2    | 1    |                 |           |       |              |              |       |
| Other                                                        |      |     |      |      |      |                 |           |       |              |              |       |

Beyond Initial Practice

| Professional School Admission                                |      | 3   | 1    | 2    |      |                 |           |       |              |              |       |
| Research and Graduate Study                                  |      | 1   |     | 2    |      |                 |           |       |              |              |       |
| Entrepreneurship                                            |      | 1   | 3   | 2    | 2    |                 |           |       |              |              |       |
| Nonengineering Management                                   |      |     | 2    |      |      |                 |           |       |              |              |       |
| Other                                                        |      |     |      |      |      |                 |           |       |              |              |       |

Note: Numbers indicate levels of correlation between the measurement device and the desired attribute.
1 = Reasonable, 2 = Moderate, 3 = Possible
### Matrix of Engineering Education Assessment Measures

#### Post-Graduation Devices

<table>
<thead>
<tr>
<th>Desired Attribute</th>
<th>Admission to Prof. or Grad. School</th>
<th>Job Offer Acceptance</th>
<th>Average Salary</th>
<th>Payoff/Prior Career Survey</th>
<th>Post-Grad School Survey</th>
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<thead>
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<th>Desired Attribute</th>
<th>Integrated Liberal Arts</th>
<th>Leadership and Global Awareness</th>
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**Note:** Numbers indicate levels of correlation between the measurement device and the desired attribute.

1 = Reasonable, 2 = Moderate, 3 = Possible
Assessing a Specific Program

M. Dayne Aldridge, Larry D. Benefield

Following are the procedures and components an assessment program should incorporate to comply with Engineering Criteria 2000.

Two years ago, the Accreditation Board for Engineering and Engineering Technology approved Engineering Criteria 2000. This new set of eight criteria establishes a radically different basis for the accreditation of U.S. engineering programs, requiring each program to have

- educational objectives consistent with its unique mission, the needs of its various constituencies, and Engineering Criteria 2000’s specifications;
- an assessment process that demonstrates these educational objectives and their associated outcomes are being achieved; and
- a system of evaluation that shows a commitment to continuous improvement.

In a distinct departure from the old accreditation system, the new criteria give administrators and educators enormous freedom in deciding how to satisfy these requirements. This freedom represents a great opportunity, but it has generated some anxiety within the engineering education community. Faculty members and administrators alike wonder how they can design assessment systems that meet Engineering Criteria 2000’s requirements when they have no model to work from.

This article can help. It maps out the procedures and components an assessment system should incorporate to comply with Engineering Criteria 2000. Understanding how these procedures and components interrelate will help educators and administrators prepare for future ABET reviews and devise detailed systems to suit their own circumstances.

A Dual Perspective: Processes and Resources

In the past, ABET’s accreditation criteria focused almost entirely on resources. When reviewing programs, evaluators looked at any number of things, including faculty members’ qualifications, curriculum details, and the adequacy of laboratory facilities. Engineering Criteria 2000, however, takes a broader approach, focusing on both resources and processes. This new focus grew out of ABET’s awareness of the need to provide programs with more flexibility and to encourage innovation in meeting the needs of constituencies.

The Process Perspective

One of the most obvious examples of the new focus on process is Engineering Criteria 2000’s requirement that every engineering program have an assessment system. At the most basic level, this assessment system should operate through two feedback systems: the educational objectives (EO) system and the learning outcomes (LO) system.

The Educational Objectives System

Educational objectives are broad, general statements that communicate
how an engineering program intends to fulfill its educational mission and meet its constituencies' needs. A constituency is a group of people with common expectations of an educational program. To ensure that the needs of these groups are being met, engineering educators need to get input from each constituency when setting and evaluating educational objectives.

The EO system encompasses six processes involved in soliciting information from various constituencies (e.g., employers, alumni, and students) and incorporating that data into the EO selection and evaluation process.

1. **Constituency Needs Process.** This process involves surveying the various constituencies to identify their needs. To get useful data, engineering schools
Assessing a Specific Program

often have to subdivide their constituencies. For example, companies who hire engineering graduates tend to recruit on either an international/national level or a local/regional level, depending on their size and resources. To get an accurate idea of what all these businesses look for in future employees, educators must examine recruiting activity at both levels.

The analytical methods they use to gather these data should measure the relative importance of different needs within a given constituency. Educators must ensure that the results are not biased in favor of their own preconceptions about constituency needs. To avoid this bias, educators should employ proven methods for gathering such data. They can do this by testing survey instruments, for instance, with small pilot groups.

It is also important to remember that this type of information gathering tends to identify a group's perceived needs and expectations, not necessarily its real or future needs. When making curriculum decisions, educators must take into account the long lag time between students' educational process and their entry into the workplace.

2. Composite Needs Process. Constituencies often have competing and incompatible needs. For this reason, educators need to devise a process for resolving potential conflicts and setting reasonable educational objectives. No single program can meet all the needs of its constituencies and so should try to fulfill only as many as is practically possible.

3. Educational Objectives Selection Process. Educational objectives state broadly how a program will satisfy constituency needs and its educational mission. They must, however, be specific enough to differentiate the program from others. Take, for example, an electrical engineering program. Its educational objectives should be sufficiently specific to distinguish it from a mechanical engineering program. The objectives also should clearly establish that the program aims to provide students with a broad education that qualifies them to work for many types of employers rather than an education tailored to suit the needs of one type of employer.

4. Program Outcomes Selection Process. Once they have set educational objectives, educators need to select program outcomes. Program outcomes describe what graduates will be expected to know and be able to do after completing a curriculum. For example, one reasonable program outcome for a computer engineering program would be the expectation that graduates will have mastered a certain number of programming languages, such as Fortran and C++. Educators can use a matrix to demonstrate how the educational objectives and program outcomes are related (e.g., how one or more program outcomes represents the achievement of an educational objective).

Each engineering program will have its own unique combination of educational objectives and associated program outcomes. Educators must ensure, however, that their program outcomes encompass the 11 accreditation outcomes specified in Criterion 3 of Engineering Criteria 2000.

5. Educational Objectives Evaluation Process. By examining how graduates perform in the workplace in relationship to the educational objectives that shaped their education, educators can gain valuable insight into how to improve their
Assessing a Specific Program

Chapter 2—Models

program's effectiveness. At a minimum, educators should gather data from graduates to assess how well prepared they were to assume their job responsibilities.

6. Educational Objectives Improvement Process. Constituency needs do not tend to change rapidly. Thus, educational objectives should not require significant modifications that frequently. For this reason, engineering programs should repeat the processes described in this section usually only every three to six years. Until they get used to the new system, however, programs may need to make more frequent adjustments.

The Learning Outcomes System

The learning outcomes (LO) system assesses student achievement of learning objectives at three levels: the course level, the curriculum level, and the program outcomes level.

Learning objectives are statements describing knowledge or skills students are expected to acquire. These objectives can be very general or very specific, but they must 1) express mastery of one or more topics contained within a single course and 2) be linked to the program outcomes in such a way that student achievement of one or more of them demonstrates satisfaction of a single program outcome. For example, the learning objectives for an introductory computer programming course might stipulate that students must 1) understand elementary data types, control structures, input/output facilities, and program organization; and 2) demonstrate knowledge of these concepts by applying them to the development of practical problem-solving programs using one or more high-level languages such as Fortran and C++.

When setting or adjusting learning objectives, educators need to strike a delicate balance. The objectives should evaluate students' mastery of knowledge and skills in detail, but they must not be so complicated and numerous that assessment becomes too complex to manage.

Course Level. The content of a single course usually addresses several learning objectives. The students and the professor share the responsibility for achieving these objectives. Professors must develop a detailed course syllabus and select the teaching materials, instructional techniques, and appropriate methods for certifying students' performance. Students must learn the required knowledge and skills, and confirm their understanding by performing well on examinations and course projects.

Educators need to remember that a course's specified learning objectives should not and cannot encompass all that they plan to teach or everything that students may learn. Learning objectives should be viewed as the most important knowledge and skills a course imparts relative to the larger educational objectives and program outcomes. Every aspect of a course need not focus on the learning objectives. Professors do not necessarily need to change their syllabus's basic design or their teaching style to prepare for Engineering Criteria 2000. They may need only to adjust course content and/or their presentation methods slightly to include specified learning objectives.

Similarly, examinations and grading methods should include a strong focus on—but not be limited to—the skills and knowledge outlined in a course's learn-
ing objectives. Thus, preparing for Engineering Criteria 2000 might require professors to make only slight changes in these areas, such as making tests broader.

Ultimately, educators need to remind themselves that no test can ever fully measure a student's learning. Thus professors cannot rely entirely on the results of a single examination when trying to assess student achievement of assigned learning objectives.

**Curriculum Level.** A curriculum is a set of courses designed to logically develop a student's knowledge and skills. A curriculum can also be thought of as a tool for organizing and operating an educational program. By assigning learning objectives to specific courses, educators can ensure that every course in a curriculum contributes to the required program outcomes and that the curriculum as a whole satisfies the program's overall educational objectives.

**Program Outcomes Level.** To verify the achievement of program outcomes, educators will need to evaluate student success in mastering assigned learning objectives. There are several ways to do this. For example, educators could require students to achieve a succession of single objectives, such as knowing how to differentiate before attempting to integrate in calculus. Alternatively, they could decide that students' mastery of a set of objectives certifies their achievement of the outcome. For example, to demonstrate their ability to communicate effectively, students would have to provide written, oral, and graphical evidence. Lastly, educators could stipulate that students must fulfill only one of a set of objectives. For example, students might be required to achieve competency in just one specialized area of a discipline.

**The Larger Assessment Picture**

Engineering Criteria 2000 requires that the assessment system 1) demonstrate educational objectives are being measured and 2) show that the results of those measurements are being applied to further develop and improve the program's effectiveness. Educators can ensure their systems fulfill both requirements by incorporating two assessment tracks into the design: a program outcomes assessment track and a program improvement track.

**Program Outcomes Assessment Track**

This assessment track uses instructors' evaluations of whether students are achieving every course's learning objectives to measure a program's success in fulfilling its program outcomes. Educators can integrate these evaluations into the regular grading process.

For instance, students who fail to meet the minimum requirements for all of a course's learning objectives should not get passing grades. In this way, a passing grade can serve as the indicator that a student has achieved the required program outcomes. For this system to work, professors must design an examination and grading system that explicitly measures the learning objectives assigned to each course.

To graduate, students must achieve all the required program outcomes. Their achievement of these outcomes could be verified by a record of passing grades in each required course.
Program Improvement Track

This track uses assessment data to further develop and improve the program. Educators need to remember that this type of information is not necessarily the same as that needed to determine student achievement of program outcomes.

Improvement activities within this track can take different forms at the course, curriculum, and program levels.

Course Level. Professors accumulate a lot of data about individual student performance. These data will be useful in improving individual courses only if they are detailed enough to indicate why students are failing to meet minimum requirements. Otherwise, how can educators identify what changes will increase student achievement? For example, assume that evaluations show that students in a junior-level mechanical design course consistently fail to achieve one or more learning objectives. This failure can indicate a number of things: The teaching approach may not be compatible with the students' learning style. The learning objectives may not be appropriate. And/or the prerequisite sophomore-level introduction-to-design course may not be preparing students to perform at the next level.

Curriculum Level. At this level, educators and administrators should concentrate on finding ways to increase students’ achievement as they progress through the curriculum. Correlating student grades for a specific course with the course’s learning objectives, for example, generates a wealth of data that educators can use in evaluating the curriculum’s success. For example, it is possible to chart the variation in student performance among different sections of the same introductory seminar taught by different professors. Seeing this variation could motivate educators to reexamine their course design and presentation style and work to make improvements.

Data accumulated at this level also can provide important information on the interface of courses. For example, say that all seniors in one program have difficulty with a specific thermodynamics course over a period of several years. Assessment data could help educators decide between two possible strategies to solve the problem. They could make changes in the preceding introductory section, making the acquisition of more advanced math, for instance, an assigned learning objective, and thereby ensuring students are better prepared for the next course. Or they could revise the expected level of student achievement in the thermodynamics course to match more closely the course’s content and difficulty level.

Any decisions to make major changes in course content or combinations of courses should occur at this level. Ideally, the academic program overall should satisfy the competing interests of several constituencies while providing a viable course of studies for students.

Program Outcomes Level. At the program outcome level, data analysis focuses primarily on measuring student achievement of program outcomes. This process should yield information about the relative quality of student success among the required outcomes, which educators can use to help improve a specific program outcome by making changes at the curriculum and/or course levels.
The Resource Perspective

The educational objectives and learning outcomes systems constitute the process half of the Engineering Criteria 2000 assessment equation. The resource requirements form the other half. ABET bases its decision to accredit a program partly on its confidence that the program will continue to have adequate resources available for the next six years. Resources can be loosely defined as any input necessary for an educational program to achieve its stated objectives and the program outcomes required by Engineering Criteria 2000. Such inputs include the following.

Students. Students are a primary resource for any engineering program. Without qualified students, no program can exist. For this reason educators need to first ensure that the standards for admitting students to the university and the program correspond to the achievement level they expect. They then must continually evaluate, advise, and monitor currently enrolled students to ensure that their performance matches those expectations. Educators can use achievement data generated through the learning outcomes system to help track students’ performance.

Professional Standards. Each engineering program establishes its uniqueness through its educational objectives. However, all engineering programs must operate within a certain envelope, and ensure that their graduates matriculate with specific qualifications. For example, Criterion 3 stipulates that all engineering graduates must acquire certain skill sets, such as the ability to function on multidisciplinary teams. Criterion 4 outlines necessary components of the curriculum, such as one year of college-level mathematics and basic sciences.

Faculty, Facilities, and Institutional Support Services. These general requirements draw on ABET’s knowledge of the infrastructural support a program must have to provide an acceptable engineering program and maintain a satisfactory level of performance between accreditation visits.

Program Criteria. Institutions granting degrees in certain specific engineering disciplines must satisfy a number of additional requirements related to curricular topics and faculty qualifications. These additional requirements are expressed in the program criteria.

Preparing for the Accreditation Visit

Under Engineering Criteria 2000, a program does not receive accreditation simply by demonstrating that it has achieved its educational objectives and program outcomes. The program also must demonstrate that it has a commitment to continuous improvement and the stability to continue its achievement record over the next six years.

Engineering Criteria 2000’s focus on process will require parts of the accreditation process to be restructured. Specifically, an ABET visit may be more of an audit of ongoing processes than a review of data supplied through a self-study document.

ABET is still developing the details of how it plans to conduct accreditation visits, but some differences are already clear. The institution will prepare a self-
study document for each engineering program before the ABET team’s visit. Because each institution has a great deal of freedom under Engineering Criteria 2000 to choose its own feedback systems and processes, the documents each institution gives ABET evaluators will have to include detailed descriptions of those systems and processes as well as supply evidence that they are yielding the intended results. The need to show results will be particularly important in relation to demonstrating that educators and administrators are using information generated by the internal assessment system to help further develop and improve the program.


ABET evaluators also can be expected to place much greater emphasis on verifying the operation of the processes within the educational outcomes and learning outcomes systems. For example, they will likely audit the records of process activity to ensure that processes are ongoing and serve as the basis for decision-making and program improvement activities.

Looking Ahead to 2000

The assessment model presented in this article provides engineering educators and administrators with a base from which to begin developing a transition plan to Engineering Criteria 2000. Every institution should expect to alter the model to meet its own specific needs. However, each university should adopt a single model for all its engineering programs because some assessment processes must operate at the institutional level and many resource issues can only be addressed at that level. Naturally, programs within a specific engineering college may differ in how they choose to implement that model, but relying on one model could greatly enhance the ABET accreditation review process.

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Larry D. Benefield is associate dean for academics at Auburn’s engineering college.
Chapter 2—Models

Assessing a Project or Course

Barbara M. Olds, Ronald L. Miller

Here’s how to design an evaluation plan for your next educational research project.

Technical research has long been a priority for engineering faculty members. In recent years, educational research has become an important activity for them as well. In general, these educational research projects aim to enhance student learning through improved curriculum and/or teaching/delivery methods.

Through our own work as educational researchers, we’ve found that rigorous assessment and evaluation are just as essential in educational research as they are in engineering research. Assessment—collecting and analyzing data—and subsequently, evaluation—interpreting and reporting findings about the data—help educational researchers measure the success of their efforts. A well-designed evaluation plan, which provides a structure for both the evaluation process and the assessment process that leads up to it, can greatly aid educational researchers.

An effective plan can help researchers gather valid assessment data, which they can use to monitor the project’s progress and guide midcourse improvements (this is known as formative assessment); or to determine if the project was successful upon completion (this is known as summative assessment). Summative assessment can help decision makers determine how to proceed once researchers complete the initial project—whether to continue funding; increase the funding; disseminate the innovation to other sites; continue the project on a probationary status; or discontinue the project.

In response to a national call for accountability across higher education, assessment and evaluation have recently gained importance and are now being mandated by accrediting organizations, funding agencies, and universities. Evidence of this includes ABET’s new Engineering Criteria 2000—which has a requirement for outcomes-based assessment—and the National Science Foundation’s increased emphasis on project evaluation.

Both of us are actively involved in this area of emerging importance. Barbara is assessment director for the Colorado School of Mines (CSM), and Ron is on the CSM assessment committee and is assessment coordinator for CSM’s chemical engineering department. We’ve assessed and evaluated CSM educational projects funded by the National Science Foundation, the National Endowment for the Humanities, and the U.S. Department of Education. Additionally, we’ve served as consultants on projects at other schools and have presented a workshop on project assessment and evaluation at a recent NSF conference.

We have learned from experience some of the “do’s and don’ts” of assessing and evaluating educational projects. In this article, we will introduce a matrix to help you develop an evaluation plan for educational research projects. We’ll also show how to use the matrix with three types of projects.
Assessing a Course or Project

### The Project Evaluation Matrix

Although collecting assessment data and analyzing the results may be more complex in educational research projects than in technical projects, the goal is the same—to determine as reliably as possible if the stated project objectives have been met. The process for doing so is also similar.

We have found that the easiest way to begin developing a project evaluation plan is to use the evaluation matrix shown below, which we expanded from a similar matrix included in the User-Friendly Handbook for Project Evaluation. This excellent source on project evaluation was written for NSF by Floraline Stevens, Frances Lawrenz, and Laure Sharp, and edited by Joy Frechtling. We are also indebted to the outcomes assessment plan developed by Gloria Rogers and Jean Sando and reported in their excellent monograph, Stepping Ahead: An Assessment Plan Development Guide.

Our project evaluation matrix provides a structure for developing an evaluation plan via a series of questions. By answering the questions, you actually articulate an evaluation plan. Thus, the matrix provides a “hands-on” concrete tool for guiding assessment plan development; it is not an abstract document that simply lists what needs to be done.

The matrix questions help to develop the following aspects of the evaluation plan:

- research question(s)
- performance criteria
- implementation strategies
- evaluation methods
- timeline
- audience and dissemination strategies.

You should treat each of these aspects as iterative and fluid as the project progresses. Here’s a closer look at each aspect.

**Research Question(s).** Developing clear and measurable research question(s) is the key to a successful evaluation plan. Many educational researchers have good ideas about general project goals, but they rarely spend the time necessary to articulate clear research questions before they undertake the project.

To formulate effective questions, ask the following, as indicated in the evaluation matrix: “What are the project objectives?” and “What questions corresponding to these objectives do we need to answer to determine if our project has been successful?” Be as specific as possible in composing your research questions.

Too often, researchers pose vague questions that are difficult to answer. Say you’re developing software to measure the intellectual development of college students. A weak research question would be: “Does the software work?” The question is flawed because it doesn’t specify what it means for software to “work.” A much clearer question would be: “Do results from the software agree with results from other expert sources?”

An example of another vague research question is: “Do students know
more about design after completing the new design course?" Again, a term like "know more" is unclear. The question becomes much more focused when rephrased as: "After completing the new design course, can students articulate the design process and use it to complete a project?"

Articulating clear research questions also forces researchers working together to agree on the project's goals and objectives and to clarify vague terms. For example, although everyone might not agree with our rephrasing of the example questions, a group working to clarify these questions would be forced to reach a consensus on how to define terms such as "works" and "know more."

**Performance Criteria.** For each research question, you should articulate specific performance criteria. A performance criterion defines the performance level required to meet the objective and indicates the types of data that will be used to provide supportive evidence.

To develop appropriate criteria, ask these questions: "How will we know that we've met our objectives?" and "What level of performance meets each objective?"

For example, in a project designed to improve the retention of electrical engineering students by developing a special introduction-to-engineering course, you might create the performance criterion that "75 percent of the students who take the pilot course will remain in electrical engineering two semesters after the end of the new introductory course."

**Implementation Strategies.** The implementation strategies are the meat of the project—they're the actual methods researchers employ to reach their project's objectives.

In developing an implementation strategy, ask: "How can we achieve our objectives?" and "Which project activities help to meet each objective?"

Implementation strategies should mesh closely with the research questions and performance criteria. Successful implementation strategies will allow you to answer your research questions positively and to meet the performance criteria.

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### Project Evaluation Matrix

<table>
<thead>
<tr>
<th>Research Question(s)</th>
<th>Performance Criteria</th>
<th>Implementation Strategy</th>
<th>Assessment &amp; Evaluation Methods</th>
<th>Timeline</th>
<th>Audience Dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the project objectives? What questions corresponding to these objectives do we need to answer to determine if our project has been successful?</td>
<td>How will we know that we've met our objectives? What level of performance meets each objective?</td>
<td>How can we achieve our objectives? Which project activities help to meet each objective?</td>
<td>What measurements will we need to make to determine if our project has been successful? On whom will we make these measurements?</td>
<td>When should we make the measurements?</td>
<td>Who needs to know the results? How can we convince them that the project met its objectives?</td>
</tr>
</tbody>
</table>
Without appropriate and effective implementation strategies, you are unlikely to achieve your objectives—no matter how wonderful the objectives are. We've seen evaluation plans with numerous lofty goals for student achievement that are never attained because faculty members have instituted no specific curricular changes to meet these goals.

For example, if students are to learn the design process, acquire communication skills, or gain an understanding of contemporary issues, they must have an opportunity within the curriculum to develop these skills. Just as an engineering researcher carefully plans an experiment, so too an educational researcher must carefully plan implementation strategies to meet specific goals and objectives.

Assessment and Evaluation Methods. The next step is to select methods for assessing and evaluating the project. To do this, ask: “What measurements will we need to make to determine if our project has been successful?” and “On whom will we make these measurements?”

A variety of assessment methods exist, including quantitative instruments—such as questionnaires and standardized exams—and qualitative instruments—such as surveys, focus groups, ethnographic studies, and protocol analysis. Which methods you select depend on many factors, including the amount of time and money available, but several general guidelines apply:

- Explore a range of possible methods—qualitative and quantitative, formative and summative—and select those that match best with your research questions and performance criteria.
- Whenever possible, use more than one assessment method to ensure more reliable results.
- Realize that it may be difficult or impossible to obtain purely objective results for this type of research. However, it is possible to measure very difficult questions with a high degree of precision and reliability.
- The data collection process should consider the needs of the respondents—whether they be students, faculty members, alumni, or employers—and should pose as little disruption as possible to them.
- Data collectors should be unbiased and trained in collection procedures.

Timeline. The key question here is: “When should we make the measurements?” The answer depends largely on whether you’re conducting a formative or summative assessment. If it’s formative, you’ll need to collect data during the project so that you can use the information to improve the project midcourse. If it’s summative, you’ll need to collect data for dissemination purposes soon after the project ends. Beyond that, our only advice is to collect data when it makes sense—at the end of a semester or a project task, for example.

Once you’ve determined the best time to collect data, you can establish a timeline for the following other steps in the assessment process:

- prepare data for analysis
- analyze data based on stated performance criteria
- conduct other analyses, if appropriate
Assessing a Course or Project

I integrate and synthesize findings into a coherent evaluation of the project.

Audience/Dissemination. Here the key questions are: “Who needs to know the results?” and “How can we convince them that the project met its objectives?”

From the beginning of a project, you should identify stakeholders and analyze their needs. Different audiences clearly have different agendas and will need different information to be convinced that the project was a success. Customize evaluation results to meet the information needs and time demands of various audiences.

For example, a funding agency such as NSF might be interested in the effect of a newly developed course on aggregate student learning, while college administrators will be interested in the cost/benefit analysis of the course, and parents will be interested in how well their own children learn in the course. All are valid issues; an evaluation plan must address each audience’s unique concerns.

Evaluation Plan Examples

Let’s see how educational researchers might use the six-part matrix we’ve described to design evaluation plans for three different types of projects.

Software Development Project. Let’s say, for example, that researchers are developing expert-system software to measure the intellectual development of college students. As shown in Example 1 (page 41), a clear and measurable research question for this project is: “Do results from the expert-system software agree with results from human experts?” The performance criterion specifies a target statistical value of the correlation coefficient that compares results obtained with the software to those of traditional interview measurements.

The implementation strategy is to write the beta version (the second overall version and the first one to be extensively evaluated) of the software. The assessment and evaluation strategy is to collect data using both the software and traditional interview methods and to compare the results statistically. The timeline specifies that researchers will complete these measurements during the second year of the project, after they’ve written the beta version of the software.

The research team will use statistical results to improve the software. Researchers will also disseminate their results to educators who are interested in using a computer system to measure intellectual development.

Retention Project. As a second example, consider a project in which a university is developing an introduction-to-engineering course to retain more of its engineering students (see Example 2, page 42). A fundamental research question for this project is: “Do students who take the new course remain enrolled in the engineering college at a higher rate than their peers, with similar backgrounds, who don’t take the course?” The performance criterion specifies an expected level of improvement in retention—in this case that the retention
rate of students completing the course will be 20 percent higher than the retention rate of their peers.

The implementation strategies involve developing and delivering an introduction-to-engineering course aimed to increase retention through a variety of strategies, including giving students an introduction to the engineering profession and helping them develop study skills.

The assessment and evaluation methods involve collecting and statistically comparing enrollment data for students in the course with enrollment data for their nonparticipating peers. This might also involve a more sophisticated multivariate statistical analysis to separate other institutional effects from the effect of the new course.

The timeline specifies collecting data at the end of each semester. Researchers will use the data to improve the project and to convince administrators to institutionalize the project curriculum.

Curriculum Development Project. This project aims to introduce engineering and science graduates to other engineering and scientific disciplines through a series of three-week modules (see Example 3, page 43). One research question for this project might be: “Do students have a better knowledge of other technical disciplines after completing the three-week modules?”

The performance criteria specify that students are expected to demonstrate above average competency in at least 50 percent of the subject modules and demonstrate satisfactory growth in 90 percent of the modules. The implementation strategy to achieve this involves developing appropriate subject modules and using them in the project.

Faculty members evaluate the effect of the modules by assessing both the technical competence of each student and the growth demonstrated by each student at the completion of each module. Students receive assessment results for formative feedback and faculty members receive results for summative feedback.

Conclusion

As our examples illustrate, the matrix provides a useful way to begin the process of developing effective evaluation plans that can help you measure the success of your educational projects. Assessment and evaluation are not easy tasks, but we hope that the matrix provides a structure that will help you begin these processes and improve the quality of your educational research projects.

Barbara M. Olds is director of the McBride Honors Program at the Colorado School of Mines. Ronald L. Miller is a chemical engineering professor at the Colorado School of Mines. The authors would like to thank Joy Pauschke and Mary Poats from the National Science Foundation for their help in preparing this article.
**Example 1—Evaluation Plan for Software Development Project**

**Goal:** Develop expert-system software to measure the intellectual development of college students

<table>
<thead>
<tr>
<th>Research Question(s)</th>
<th>Performance Criteria</th>
<th>Implementation Strategy</th>
<th>Assessment &amp; Evaluation Methods</th>
<th>Timeline</th>
<th>Audience Dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do results from the expert-system software agree with results from human experts?</td>
<td>Software is deemed reliable if correlation coefficient exceeds 0.8 for software and traditional interview methods when using a sample of 20 students.</td>
<td>Write the beta version of the software.</td>
<td>Collect data using the beta version of the software and traditional interview methods. Statistically compare the results.</td>
<td>Collect data during the second year of the project after we’ve written the beta version of the software.</td>
<td>Statistical results will be used by human experts and programmers to improve software. Faculty members will use the software to measure the intellectual development of college students.</td>
</tr>
</tbody>
</table>

Do results from the expert-system software agree with results from human experts?

Software is deemed reliable if correlation coefficient exceeds 0.8 for software and traditional interview methods when using a sample of 20 students.

Write the beta version of the software.

Collect data using the beta version of the software and traditional interview methods. Statistically compare the results.

Collect data during the second year of the project after we’ve written the beta version of the software.

Statistical results will be used by human experts and programmers to improve software. Faculty members will use the software to measure the intellectual development of college students.
### Example 2—Evaluation Plan for Retention Project

**Goal:** Improve retention of engineering students by establishing an introduction-to-engineering course

<table>
<thead>
<tr>
<th>Research Question(s)</th>
<th>Performance Criteria</th>
<th>Implementation Strategy</th>
<th>Assessment &amp; Evaluation Methods</th>
<th>Timeline</th>
<th>Audience Dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do students who take the new course remain enrolled in the engineering college at a higher rate than their peers with similar backgrounds?</td>
<td>Retention rate of students completing the course will be 20 percent higher than retention rate of their peers.</td>
<td>Develop and implement an introduction-to-engineering course designed to improve the retention of targeted populations.</td>
<td>Collect and statistically compare enrollment data for students in the project with data for their peers.</td>
<td>Collect data at the end of each semester of the project.</td>
<td>Researchers will use the results to improve the course and to convince administrators to institutionalize the course.</td>
</tr>
</tbody>
</table>

- **Research Question(s):** What are the project objectives? What questions corresponding to these objectives do we need to answer to determine if our project has been successful?

- **Performance Criteria:** How will we know that we've met our objectives? What level of performance meets each objective?

- **Implementation Strategy:** How can we achieve our objectives? Which project activities help to meet each objective?

- **Assessment & Evaluation Methods:** What measurements will we need to make to determine if our project has been successful? On whom will we make these measurements?

- **Timeline:** When should we make the measurements?

- **Audience Dissemination:** Who needs to know the results? How can we convince them that the project met its objectives?

- **Do students who take the new course remain enrolled in the engineering college at a higher rate than their peers with similar backgrounds?**

  - Retention rate of students completing the course will be 20 percent higher than retention rate of their peers.

  - Develop and implement an introduction-to-engineering course designed to improve the retention of targeted populations.

  - Collect and statistically compare enrollment data for students in the project with data for their peers.

  - Collect data at the end of each semester of the project.

  - Researchers will use the results to improve the course and to convince administrators to institutionalize the course.
### Example 3—Evaluation Plan for Curriculum Development Project

**Goal:** Introduce engineering graduates to other technical disciplines using three-week modules

<table>
<thead>
<tr>
<th>Research Question(s)</th>
<th>Performance Criteria</th>
<th>Implementation Strategy</th>
<th>Assessment &amp; Evaluation Methods</th>
<th>Timeline</th>
<th>Audience Dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the project objectives? What questions corresponding to these objectives do we need to answer to determine if our project has been successful?</td>
<td>How will we know that we've met our objectives? What level of performance meets each objective?</td>
<td>How can we achieve our objectives? Which project activities help to meet each objective?</td>
<td>What measurements will we need to make to determine if our project has been successful? On whom will we make these measurements?</td>
<td>When should we make the measurements?</td>
<td>Who needs to know the results? How can we convince them that the project met its objectives?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do students have a better knowledge of other technical disciplines after completing the three-week modules?</th>
<th>Develop and use subject modules throughout the course.</th>
<th>Faculty will assess competence at the end of each module and growth during the module. Students will assess themselves at the end of each module.</th>
<th>Faculty will assess competence at the end of each module and growth during the module. Students will assess themselves at the end of each module.</th>
<th>Students receive assessment results after each module for formative feedback. Faculty members receive results for summative feedback.</th>
<th></th>
</tr>
</thead>
</table>

- **Assessment:**
  - Students will demonstrate above average competency in 50 percent of the modules and satisfactory growth in 90 percent of the modules.
  - Students will assess themselves at the end of each module.

- **Faculty:**
  - Faculty will assess competence at the end of each module and growth during the module.
  - Students will assess themselves at the end of each module.

- **Audience Dissemination:**
  - Students receive assessment results after each module for formative feedback. Faculty members receive results for summative feedback.
Basic Assessment Principles

The Assessment Forum of the American Association for Higher Education suggests basing student assessment practices on the following tenets.

1. The assessment of student learning begins with educational values. Assessment is not an end in itself but a vehicle for educational improvement. Its effective practice begins with and enacts a vision of the types of learning we most value for students. Where questions about educational mission and values are skipped over, assessment threatens to be an exercise in measuring what's easy, rather than a process of improving what we really care about.

2. Assessment is most effective when it reflects an understanding of learning as multidimensional, integrated, and revealed in performance over time. Learning entails not only what students know but what they can do with what they know; it involves not only knowledge and abilities but values, attitudes, and habits of mind that affect both academic success and performance beyond the classroom. Assessment should reflect these understandings by employing an array of methods, using them over time to reveal change, growth, and increasing degrees of integration.

3. Assessment works best when the programs it seeks to improve have clear, explicitly stated purposes. Assessment is a goal-oriented process. It entails comparing educational performance with educational purposes and expectations—those derived from the institution’s mission, from faculty intentions in program and course design, and from knowledge of students’ own goals. Where program purposes lack specificity or agreement, assessment pushes a campus toward clarity. Assessment also prompts attention to where and how program goals will be taught and learned.

4. Assessment requires attention to outcomes, but also and equally to the experiences that lead to those outcomes. Where students “end up” matters greatly. But to improve outcomes, we need to know about student experience along the way—about the curricula, teaching, and type of student efforts that lead to particular outcomes. Assessment can help us understand which students learn best under what conditions; with such knowledge comes the capacity to improve the whole of their learning.

5. Assessment works best when it is ongoing. Though isolated, “one-shot” assessment can be better than none, improvement is best fostered when assessment entails a linked series of activities over time. This may mean tracking the process of individual students or of cohorts of students; it may mean collecting the same examples of student performance or using the same instrument semester after semester. The point is to monitor progress toward intended goals in a spirit of continuous improvement. Along the way, the assessment process itself should be evaluated and refined in light of emerging insights.

6. Assessment fosters wider improvement when representatives from across the educational community are involved. Faculty members play an important
role, but assessment questions can't be fully addressed without participation of student-affairs educators, librarians, administrators, and students. Assessment may also involve individuals from beyond the campus (alumni, trustees, employers) whose experience can enrich the sense of appropriate aims and standards for learning. Assessment is not a task for small groups of experts but a collaborative activity of all parties with a stake in the improvement of student learning.

7. **Assessment makes a difference when it begins with issues of use and illuminates questions that people really care about.** To be useful, assessment information must be connected to issues or questions that people really care about. This implies assessment approaches that produce evidence that relevant parties will find credible, suggestive, and applicable to decisions that need to be made. It means thinking in advance about how the information will be used, and by whom.

8. **Assessment is most likely to lead to improvement when it is part of a larger set of conditions that promote change.** Assessment's greatest contribution comes on campuses where the quality of teaching and learning is visibly valued. On such campuses, the push to improve educational performance is a primary goal of leadership; improving the quality of undergraduate education is central to the institution's planning, budgeting, and personnel decisions. On such campuses, information about learning outcomes is seen as an integral part of decision making, and is avidly sought.

9. **Through assessment, educators meet responsibilities to students and to the public.** As educators, we have a responsibility to the publics that support or depend on us to provide information about the ways in which our students meet goals and expectations. But that responsibility goes beyond the reporting of such information; our deeper obligation is to improve. Those to whom educators are accountable have a corresponding obligation to support such attempts at improvement.
Glossary of Terms

M. Dayne Aldridge, Larry D. Benefield

Many of the terms in Engineering Criteria 2000 do not have standardized meanings within the engineering education community. The following glossary offers concise definitions.

**Educational Objectives System:** The set of all processes and activities used to meet the requirements of Criterion 2.

**Learning Outcomes System:** The set of all processes and activities used to meet the requirements of Criterion 3.

**Constituency:** A group of people with common expectations of an educational program.

**Constituency Need:** What a constituency expects to get in return for its investment in an educational program.

**Educational Objectives:** Broad statements describing how a program will satisfy constituency needs and fulfill its mission.

**Program Outcomes:** Descriptions of the knowledge and/or skills graduates are expected to have after completing the curriculum.

**Specified Accreditation Outcomes:** The 11 outcomes listed in Criterion 3 and required of all engineering programs.

**Learning Objectives:** Statements describing specific knowledge and/or skills students are expected to acquire.
Student Portfolios

Beth Panitz

More than just a collection of coursework, the portfolio offers an effective way to evaluate a student’s progress.

Keeping a portfolio of one’s work is not a new idea—architects, artists, and writers have been doing it for some time. More recently, though, educators in a variety of fields, including many in engineering, have been using the portfolio as a way to collect and evaluate student work.

The theory behind such portfolios is that examining a student’s work over a period of time provides a holistic assessment that demonstrates whether a student is progressing toward and truly achieving educational goals. Supporters of portfolio assessment contend that portfolios show evidence of skills that exams and standardized tests, or even papers or projects evaluated separately, cannot. Of course, these other assessment methods have their advantages, and portfolios are often used in combination with them.

While the primary goal of student portfolios is assessment, portfolio formats can vary greatly, depending on who is assessing what. In some cases, faculty members use student portfolios to assess individual students; in other cases, students use them to assess their own work; and in still other cases, school administrations use them to assess the effectiveness of the overall curriculum.

The length of time a portfolio covers also varies. A particular teacher may institute portfolios for assessment throughout a course. Or portfolios may be part of a larger assessment plan, led by the school or department, in which work is collected throughout the entire curriculum or for a specific area of the curriculum, such as design. While a portfolio that covers just one course may include a majority of the student’s work for that course, longer-term portfolios tend to be more selective.

“Both types of portfolios are valuable,” says Patrick Courts, coauthor of Assessment in Higher Education: Politics, Pedagogy, and Portfolios. In fact, he suggests combining the two approaches by requiring students to keep portfolios for particular courses and then to draw from these course portfolios to create a portfolio that represents work throughout the curriculum.

The classwork samples (sometimes called artifacts) collected in a portfolio may include papers, projects, design work, CAD drawings, and videotapes of oral presentations. At some institutions this portfolio of work is used not only as an assessment tool but also as a marketing device for job searches and a reference aid for students to use in future courses or on the job.

Following are accounts of how five institutions have designed portfolio formats that meet their unique needs.
When faculty members at the City University of New York's Borough of Manhattan Community College (BMCC) revamped the school's calculus courses in 1989 to incorporate several computer projects, they also added a portfolio requirement. Originally the calculus portfolio was simply a compilation of the student's projects and a way to encourage students to hold on to their work in an organized fashion, says mathematics professor Larry Sher. For example, in Sher's Calculus I class, students were required to hand in a portfolio containing three of their five computer projects.

When faculty members discussed the portfolio requirement at an interdepartmental meeting, the school's writing-across-the-curriculum group suggested expanding the portfolios to include an essay in which students reflect upon their work. “The writing-across-the-curriculum people said the students needed to give some information about the things in their portfolio in order to make them think more deeply about what they were learning,” Sher explains.

Now along with including three of their five computer projects, students write an essay of two to four pages in which they explain why they chose those three projects, what they learned about calculus from those projects, and how using computer technology helped their learning. The portfolio accounts for approximately 20 percent of a student's grade, with the other 80 percent based on tests and quizzes. Similar portfolios are required in Calculus II and III.

Sher views the essay as an essential part of the portfolio. He explains that the essay not only requires students to reflect on what they've learned but also helps them develop communication skills. “Students not only do math but have to write about it in English, in full sentences,” he says.

John Romo, who took all three calculus classes last year from Sher, says writing the reflective essay allowed him to leave the class aware of the skills he had learned and the areas he had originally struggled with but eventually mastered.

Sher points out that a well-prepared portfolio can give students an edge when applying for a job or (in the case of students at his school) for admission to a four-year university. Sher recounts that in an admissions interview with an Ivy League university, one of BMCC's students presented her portfolio. The student received a scholarship and told Sher she believes one reason was that her portfolio impressed the admissions officer.

Because of their positive experiences with portfolios in calculus, BMCC faculty members are currently working on creating portfolio requirements for physics, chemistry, and computer science courses through a grant from the National Science Foundation. Eventually the school plans to produce a faculty manual about using portfolios across scientific disciplines.
At the University of Colorado, Anthony Songer, an assistant professor in the department of civil, environmental, and architectural engineering, uses a similar approach to portfolios in his graduate-level course on construction management. But in Songer's class, the students keep all of their class material in the portfolio, including assignments, class notes, and handouts.

In a short essay, students indicate which assignments in the portfolio they want their course grade to be based on and why. Students also indicate how much weight should be put on each category of their work. For example, students must select three out of six article summaries that they completed throughout the semester and assign the category 5 to 15 percent of their overall grade. (Students are required to hand in only the assignments that they want to count toward their final grade, but many of them include all of their assignments so that they'll have a complete record of their work.) Students also specify the most important thing they learned in each module of the class.

The portfolio counts for 100 percent of a student's grade. The classwork within the portfolio usually counts for 90 percent of the grade, while the justification accounts for the other 10 percent. Making the justification a part of the grade causes students to seriously assess their progress and reflect on what they've learned, Songer says. "Otherwise, they would just slap something together."

Although students don't turn in their portfolios until the end of the semester, Songer does review the assignments throughout the term. But instead of giving the students a flat grade at the time, he tells students what range their work is in and gives them suggestions for improvements. Students then have the opportunity to improve the assignment and include both versions in their portfolio. "Those that do, raise their grade dramatically," he says.

The portfolio format allows him to grade his students more holistically, Songer says. Rather than just averaging the students' grades from throughout the semester, he looks at their progress as a whole. "If I see that someone's really tried and really improved, I'll give him or her a higher grade," he says. The approach seems to work especially well in his class, which is composed mostly of projects and written assignments, not exams, Songer notes. But, he admits, this grading method also requires more time. While he doesn't mind the extra effort in this course, which has only 15 to 20 students, he says that in a larger class it would become too time-consuming.

Some of his students have come to appreciate the portfolio not only as a form of self-assessment, but as a reference tool to use throughout their careers, Songer says. "They look at it as something they're going to have on their shelves," he says. "If their boss says to them, 'What do you know about TQM?,' they'll have someplace to look it up fast."

Not all students like portfolio assessment. "Some of them don't want to break out of the boundaries of what they think a class should be," Songer says. "They just want to be lectured to and have three tests."
#3: Demonstrating Competencies
Arizona State University

Lynn Bellamy, an associate professor of chemical engineering at Arizona State University (ASU), agrees with Songer and Sher that to be effective as a self-assessment tool, a portfolio needs to be more than just a collection of a student’s work.

To make his students reflect on the value of their work, Bellamy requires that they fill out a “competency matrix,” which indicates what skills each item in the portfolio demonstrates. On one axis of the matrix, learning outcomes such as “teaming” and “creative problem solving” are listed along with subcategories. On the other axis, learning levels are listed. Bellamy breaks the learning levels into two categories: affective objectives (based on Krathwohl’s Taxonomy) and cognitive objectives (based on Bloom’s Taxonomy). Students use the matrix as the index of their portfolios, indicating within the grid the page numbers of assignments that show evidence of certain skills. (See sample on next page.) Bellamy and Barry McNeill, an assistant professor of mechanical and aerospace engineering at ASU, adapted the matrix from a similar form used in a high school in Alaska.

“The portfolio is not so much for the instructor [to evaluate the students] as for the students to demonstrate their learning,” Bellamy says.

Bellamy requires portfolios in both his sophomore/junior level engineering science course and his freshman introduction-to-engineering course. In his freshman course, which has about 350 students, students divide into design teams of four, and each team keeps a portfolio of its design work. As a group, students complete the competency matrix. McNeill uses portfolios in his senior courses, including senior design. Because of the nature of his courses, his portfolios tend to include fewer but more complex assignments.

Currently, Bellamy’s students hand in their portfolios three or four times throughout the semester. He checks to see that the portfolios are up-to-date and provides feedback. Next year, Bellamy plans to require that the portfolios be in electronic format so that he can access and evaluate them online. He anticipates that this will be an easy transition because the students already do most of their work on computer and will be able to scan in any hard copy.

Because maintaining a portfolio with a detailed competency matrix requires a considerable amount of time, Bellamy says that he has reduced the homework load in exchange. “It’s really hard when you finish an assignment to have to pick it apart and examine your learning,” he says. “It’s not the classical approach that students are used to in which ‘If I do my homework, and I get the right answer, I’m out of here.’”
Some portfolios contain a competency matrix that students use to indicate how the portfolio contents meet pre-established learning outcomes. Following is a section of the competency matrix Lynn Bellamy of Arizona State University uses with his students. A full copy of the matrix can be downloaded from the World Wide Web, www.public.asu.edu/~ece100.

### The Competency Matrix

<table>
<thead>
<tr>
<th>Learning Outcome</th>
<th>Competency Category</th>
<th>Competencies (bolded boxes are required)</th>
<th>Cognitive Objectives</th>
<th>Affective Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Getting Started</td>
<td>Problem-Solving Heuristic 4.2 - 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(continued)</td>
<td></td>
<td>Define (Problem) 4.2 - 13</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Generate (Alternatives) 4.2 - 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decide (Course of Action) 4.2 - 15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Implement (Solution) 4.2 - 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaluate (Process) 4.2 - 17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creative Problem Solving</td>
<td>Interpersonal Interactions 4.2 - 18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customer 4.2 - 19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Teams 4.2 - 20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The letters in each box indicate in which session(s) of the class the competency is (could be) achieved: C = Concepts, M = Modeling, and L = Laboratory. Grayed boxes reflect levels not expected to be achieved during the course. "Fog." refers to a course textbook.
At Fairfield University's BEI School of Engineering, the portfolio is solely a tool for students and is not graded by faculty members. Starting at the end of their sophomore year, students must maintain a portfolio of their design work, says Richard Weber, associate dean of engineering. Students use these portfolios for self-assessment and self-recognition. “When the students look at their portfolios and compare where they were to where they’ve come, they realize that they’ve had significant growth,” Weber says.

As students start new design projects, they often refer to the earlier work in their portfolios. And when students meet with faculty mentors to discuss their projects, they are encouraged to bring along their portfolios as a way of demonstrating their experience base, Weber says.

In addition to maintaining a design portfolio, faculty members encourage students to keep another, larger, portfolio of all of their work. Ellis Cooper, a senior mechanical engineering major, keeps all of his work—notes, homework, tests, and projects—organized by class, in a large box. “I know exactly where everything is,” he says, noting that often he’ll refer to his past notes and assignments. He also has computer disks organized by class with electronic copies of some of his assignments.

“All of our professors work in industry, and they know how important it is to keep good records and good documentation,” Cooper says.

While keeping a portfolio requires some time, “it’s actually a time-saver in the long run,” says senior John O’Neill, who organizes all of the material that he has amassed since he started BEI in 1986. O’Neill, who works full time as a technician, says that by keeping a portfolio in school he has developed organizational skills that help him on the job.

BEI faculty members also urge their students to examine their portfolios and select the best items to form a more appropriate portfolio to take on job interviews. “If you’ve got that portfolio under your arm, you’ve got a tremendous tool,” Weber says.
Student Portfolios

Student portfolios assume a much different role at the Colorado School of Mines (CSM) than at the other schools mentioned in this article. A portfolio at CSM is also a collection of classwork, but faculty members, not students, maintain the portfolios. CSM implemented its portfolio approach in 1988 after the Colorado legislature mandated that every state institution annually perform a thorough assessment of its academic programs.

CSM considered several assessment options and “chose portfolios because they don’t rely on just one measure,” says Barbara Olds, chair of CSM’s assessment committee. “Portfolios offer a richness of data that standardized tests and other assessment tools don’t.”

In order to assess the curriculum, the school maintains portfolios for a statistically selected sample of students throughout their entire academic career at CSM. Based on the school’s goals for its graduates, the assessment committee picks which items to include in the portfolios. To demonstrate communication skills, for example, the portfolios include writing samples as well as videotapes of oral presentations.

“If you’re careful in selecting what goes into the portfolio, a single item can be used to assess several things,” Olds says. A design project report, for example, demonstrates technical ability, communication skills, teamwork, and leadership ability. Portfolio items are taken from only about a quarter of the courses.

“This really comes out of the quality management movement,” notes Mike Pavelich, a chemistry professor who serves on the assessment committee. “You write down what you’re trying to achieve, and then you measure it.”

At the end of each school year, the assessment committee evaluates the portfolios in terms of showing evidence of the school’s goals. While the process is not too time-consuming—it usually takes about two days—Olds points out that “you have to have faculty members who are willing to be involved.” Usually the committee is composed of about eight faculty members.

The biggest challenge CSM has found with portfolio assessment, Olds says, is disseminating information about the committee’s recommendations and getting faculty and administrators to make changes based on the recommendations.

Pavelich points out, however, that the school has used the committee’s findings to make several constructive changes. For example, he says, in evaluating the portfolios, committee members found a deterioration in the students’ writing skills. In response, the school hired writing specialists. In other instances, the committee provided feedback to specific professors about how to grade exams or structure writing assignments.

Currently CSM is revising its curriculum and plans to use portfolio assessment to evaluate whether the curriculum changes are successful.
TIPS FOR STARTING PORTFOLIOS

Patrick Courts, coauthor of Assessment in Higher Education: Politics, Pedagogy, and Portfolios, offers four suggestions for implementing student portfolios.

1) **Think about why you want to implement student portfolios.** Will portfolios be used as a way for professors to assess students, students to measure their own learning, or administrators to assess the curriculum? Will portfolios be used to examine a student's growth over a single course or throughout the curriculum? Will a portfolio showcase a student's work so that he or she can present it to prospective employers? Will the portfolio be organized as a reference tool for students to use in other classes and on the job?

2) **Decide what goes into the portfolio.** What type of skills should the portfolio demonstrate? What assignments show evidence of these skills? How much of a student's work should go into the portfolio? Will the portfolio include an assignment (such as an essay or a competency matrix) that helps students reflect on their learning?

3) **Decide what will be done with the portfolio.** Will students hand the portfolio in periodically to get feedback, just when it's complete (at the end of a course or before they graduate), or not at all? Will students meet with faculty members to discuss the learning growth demonstrated by their portfolios?

4) **Don't overshoot or try to do everything.** Start out slowly, rather than trying to use portfolios to assess everything. Be sure that the requirement is one that students will be able to understand and fulfill and that faculty members will be able to work with.

Beth Panitz is senior editor for ASEE PRISM.
Survey Questionnaires

By Vern R. Johnson

Survey questionnaires can be very helpful in assessing an engineering program's effectiveness.

Engineering educators have always thought it important to know how well their programs are doing. The Accreditation Board for Engineering and Technology's recent adoption of Engineering Criteria 2000 places an even greater premium on such information by requiring accurate, reliable data on all aspects of program performance. Educators can generate this data using many different assessment tools. This article focuses on one such instrument: the questionnaire.

Why Questionnaires?

Questionnaires are survey instruments designed to collect the opinions of a specific audience. They can assess satisfaction with a wide range of topics and provide a general idea of what respondents sense as important. This flexible nature enables engineering educators to adapt questionnaires to suit a variety of assessment purposes.

A well-designed questionnaire can provide educators with valuable information on specific modifications they need to make to improve program effectiveness. For example, say the results of a spring survey of undergraduates show that freshmen want more "hands-on" application of engineering principles. When updating the first-year introduction-to-engineering courses, faculty members could then incorporate more of these activities.

Educators can also use questionnaires to help them refine their set of program outcomes (i.e., the attributes they want graduates to have). For example, one new outcome related to the addition of more hands-on experiences to the undergraduate curriculum could be the stipulation that graduates have a basic understanding of real-world engineering.

Developing a Questionnaire

There are 10 basic steps to developing and using an effective questionnaire.

1. Select a process to assess.
2. Identify the audience to be surveyed.
3. Determine how the data will be used.
4. Decide which specific attributes of the process will be assessed.
5. Choose a scoring system.
6. Construct the questionnaire.
7. Conduct the survey and tabulate the data for analysis.
8. Analyze and interpret the data.
9. Use the interpreted data to muster stakeholder support.
10. Implement appropriate improvement projects and monitor their progress.
Using a hypothetical engineering department, let’s walk through an extended example of how engineering educators can develop a highly targeted, program-specific questionnaire using this 10-step procedure.

**Steps 1-3: Establish Basic Parameters**

A mechanical engineering department wants to assess its senior-year capstone design course (Step 1). The department decides to survey students who have already completed the course (Step 2) in the hope of gathering data it could use to improve the capstone experience (Step 3).

**Step 4: Decide Which Attributes to Assess**

Next, the team designing the questionnaire selects the course attributes that the survey will address. The mechanics involved in completing this fourth step require a little additional explanation. In selecting the attributes the questionnaire will focus on, the design team has to weigh several factors. First, it must recognize that the department may have designed the capstone course to fulfill several of the 11 accreditation outcomes required under EC 2000. These outcomes stipulate that all engineering graduates must have:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs;
- an ability to function on multidisciplinary teams;
- an ability to identify, formulate, and solve engineering problems;
- an understanding of professional and ethical responsibility;
- an ability to communicate effectively;
- the broad education necessary to understand the impact of engineering solutions in a global and societal context;
- a recognition of the need for and an ability to engage in lifelong learning;
- a knowledge of contemporary issues; and
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

To help isolate which of these outcomes the capstone design course supports, the team recasts them all as shorter statements in verb, noun format. For example, the first accreditation outcome might be: apply knowledge of mathematics, science, and engineering.

The team then examines the abbreviated list and removes the outcomes the capstone design course does not meet. It then arranges the remaining outcomes that the course does meet, such as analyzing and interpreting data, in an order that is easy for the intended audience to understand. The list might look something like this:

1. Function on a multidisciplinary team.
2. Identify a customer or industrial need.
3. Formulate descriptions of problems that when solved satisfy a need.
4. Apply mathematics, science, and engineering to solve the problems.
5. Design a component to meet desired needs.
6. Analyze and interpret data.
7. Communicate using oral progress reports.
8. Communicate using written final reports.

In all likelihood, when the mechanical engineering department developed the capstone design course's objectives, it also incorporated feedback from other stakeholders, such as alumni and prospective employers, as well as from EC 2000 requirements. The stakeholders probably enumerated skills they believed students ought to acquire from such a class. Those desired skills might include:

- the ability to use textual material to support project design
- the ability to obtain materials for project construction
- the ability to pilot-test a component prior to full implementation.

The final list of attributes to be assessed in the questionnaire includes these three skills as well as the eight distinct course objectives identified by the team. It reads as follows:

1. Function on a multidisciplinary team.
2. Identify a customer or industrial need.
3. Formulate descriptions of problems that when solved satisfy a need.
4. Apply mathematics, science, and engineering to solve the problems.
5. Design a component to meet desired needs.
6. Use text materials to support project design.
7. Obtain materials for project construction.
8. Pilot test a component prior to full implementation.
9. Analyze and interpret data.
10. Communicate using oral progress reports.
11. Communicate using a final written report.

Ideally, questionnaires should focus on no more than 10 to 15 attributes. Respondents can usually evaluate a list of this size in a few minutes before losing interest.

**Step 5: Choose a Scoring System**

After identifying attributes to be assessed, the team chooses a scoring system for the questionnaire (Step 5). Scoring should be simple and clear, but also must effectively measure respondents' satisfaction with the course's treatment of each attribute and an estimation of how the respondents view each attribute's relative importance.

A scoring system can assess satisfaction and importance directly (see Undergraduate Spring Survey on page 62). Or, educators can choose to have respondents assess satisfaction and then identify the three to six most important attributes (see Senior Capstone Design Experience Survey on page 63). This second approach works better with both faculty members and students. Often these groups consider everything to be almost equally important, but they can select the three to six most important attributes.
A scoring system of 1 to 5 or A to E is suitable for most questionnaires. Always include a score of NA for not applicable.

**Step 6: Construct the Questionnaire**

After selecting an appropriate scoring system, the team constructs the questionnaire form itself (Step 6). The form should feature an opening statement that explains the survey's purpose (to better focus course improvement efforts) and how the department plans to use the results (to identify aspects of the course that need to be improved). A set of instructions on how to complete the questionnaire follows the opening statement as well as a list of the 11 attributes and the scoring system.

Before releasing the questionnaire, the team pilot-tests the form with a group of representative students (perhaps members of a student professional society) to ensure that students will interpret the instructions correctly. Sometimes a discussion with the pilot-test group is helpful as well.

Lastly, team members draft instructions about how the respondents should submit the questionnaire to the department. (Whenever possible, arrange it so that the completed questionnaires can be picked up at the time and place of distribution. When this is not possible, the questionnaire should include instructions about where respondents should submit the completed forms. Drop boxes in key locations on campus, mail, or fax are all options.)

**Step 7: Conduct the Survey and Tabulate the Data**

A third party distributes the questionnaire to all graduating seniors who have completed the capstone design course (Step 7). To ensure a useful result, a statistically significant number of students must complete the survey.

After collecting the completed questionnaires, team members begin tabulating the data (Step 7). They can use hand calculations or spreadsheets, but both are very limiting. Many prefer to use an electronic data base with an analysis program, such as ASSESS 1.0. Engineering educators can access this free program from the Web page www.engr.arizona.edu/~acadaff/assess.zip or request the software via the following e-mail address: vjohnson@arizona.edu. Designed specifically for the University of Arizona’s engineering school, this program features a user-friendly interface and can calculate a large number of survey responses.

**Step 8: Analyze and Interpret the Data**

The team members can now begin analyzing and interpreting the data (Step 8). First, they calculate the average satisfaction and importance level for each attribute on the questionnaire. (Do not include the NA scores.) They then compute overall averages for satisfaction and importance by including all attributes. By graphing those items according to their importance and satisfaction coordinates, educators can isolate the attributes that have above-average importance and below-average satisfaction. These are the attributes that need the most attention.
In the hypothetical case described here, respondents reported overall satisfaction with their experience; however, they rated the two communication attributes above average in importance and below average in satisfaction. This finding reveals that the students believe that the course did not adequately prepare them to perform well in these important areas.

**Step 9: Use the Data to Muster Stakeholder Support**

The department can use the graphical analysis of the questionnaire’s findings to gain institutional and stakeholder support for undertaking program improvements (Step 9). This type of data presentation is often very effective in effecting changes.

**Step 10: Implement and Monitor Improvement Projects**

Once the department has attained stakeholder support (financial or otherwise), it starts work to revamp and revitalize the senior capstone design course (Step 10). As part of this effort, faculty members might draft a project statement that describes what they hope to accomplish, such as creating learning units on how to present oral progress reports. The department then assembles a team interested in tackling the course redesign. This team’s first actions would be to set a series of milestones for accomplishments and establish a reporting schedule.

**Building Your Own Repertoire**

Questionnaires are but one of the many tools (including portfolios, P.E. exam results, and alumni achievement data) that engineering educators can include in an effective assessment repertoire. When used in combination, these tools give educators a measure of how well they are doing and provide concrete information about specific steps they can take to improve their program.

Vern R. Johnson is associate dean for academic affairs in the College of Engineering and Mines at the University of Arizona.
# Undergraduate Spring Survey

Please rate the following with respect to: 1) their importance to your education, and 2) your overall satisfaction with your engineering program’s performance in these areas.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Importance</th>
<th>Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Exciting and intellectually stimulating courses</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>2. Competent professors</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>3. Faculty interest in student learning</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>4. Ability to make progress reasonable toward a degree</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>5. Academic advising</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>6. Attaining a B.S. degree in four years</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>7. Reasonable cost</td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5 NA</td>
</tr>
</tbody>
</table>
### Senior Capstone Design Experience Survey

Please indicate how well your senior capstone design course in mechanical engineering has helped you to do the following:

**RATING SCALE**
1 = Very dissatisfied  
5 = Expectations surpassed  
NA = Not applicable

<table>
<thead>
<tr>
<th>Item</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Function on a multidisciplinary team.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>2. Identify a consumer or industrial need.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>3. Formulate descriptions of mechanical engineering problems that when solved satisfy a need.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>4. Apply mathematics, science, and engineering to solve the problems.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>5. Design a component to meet desired needs.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>6. Use text materials to support project design.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>7. Obtain materials for project construction.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>8. Pilot-test a component prior to full implementation the component.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>9. Analyze and interpret data.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>10. Communicate using oral progress reports.</td>
<td>1 2 3 4 5 NA</td>
</tr>
<tr>
<td>11. Communicate using a final written report.</td>
<td>1 2 3 4 5 NA</td>
</tr>
</tbody>
</table>

Of the 11 items listed above, please go back and circle the three that you believe are the most important.
Chapter 4—Advice

Accepting the Challenge

The Accreditation Board for Engineering and Technology’s Engineering Criteria 2000 is probably topic number one whenever engineering educators gather or when departmental curriculum committees meet. And rightly so. The new engineering criteria are likely to cause the first fundamental change in the way engineering educators do business since the digital computer became truly ubiquitous in engineering schools. Furthermore, the engineering technology community is close behind as the Technology Accreditation Commission prepares its new criteria.

It’s been interesting watching engineering educators learn about the new criteria. Acceptance has been slow; in some cases grudging, and in others, incomplete. While Engineering Criteria 2000 represents the birth of something new—something most believe to be good—it also will lead to the death of something old. Indeed, we seem to be experiencing the five stages of grief Elizabeth Kubler-Ross describes in her book, On Death and Dying.

Kubler-Ross identifies five stages a person undergoes upon learning of his or her impending death: denial, anger, bargaining, depression, and acceptance.

Denial. When educators heard about the new criteria, many reacted by saying, “Don’t worry; it will never happen.” This seems to be a normal human reaction when facing unwelcome change. For many, Criteria 2000 does presage changes that will require additional work as well as cause trauma as educators struggle to let go of the old ways of doing things. For many, that’s not a happy prospect.

Anger. Once it finally becomes clear that the change is indeed coming, anger sets in. “Who do they think they are?!! They can’t tell us what to do!!” It is irritating when some group of “theys” prescribes what we must do, but consider these facts: First, the prescription isn’t really all that prescriptive. Programs have a lot of leeway in how they choose to satisfy the criteria. Second, the “they” is really us. ABET represents the engineering profession, and we’re all in it together.

Bargaining. With our anger resolved or at least dissipated, the next step is to see if we can bargain our way out of the situation. “We can’t be responsible for all 11 attributes listed in Criterion 3, so how about if we just identify six or seven, and you forget about the rest? Or, we’ll do the assessment but we won’t really worry about using the results.” But there is no deal to be made. Those attributes are all important or they wouldn’t be on the list. Assessment that isn’t used isn’t worth doing. There is not much—probably not any—room for bargaining.
Accepting the Challenge

**Depression.** “Oh, woe! Oh, gloom! If it weren’t for bad luck, I’d have no luck at all!” Once again, this is a very human reaction. When we find out that anger doesn’t help and we can’t strike a bargain, we feel like we’ve lost control of our destiny—and that is pretty depressing. But the new criteria don’t deny us control of our destiny. They actually leave a lot of room for individuality and innovation and give us freedom to do things the way we choose. In fact, some educators complain the new criteria give us too much freedom, that ABET won’t tell us how to do assessment.

**Acceptance.** Once we finally “pull up our socks,” as our mothers used to say, and decide that we’d might as well get on with it, we can accept the new situation and get to work. Eventually, this is where we will all end up—accepting the new criteria and getting down to the business of making our education system the best that it can be.

Ultimately, however, I hope there is a sixth and final stage beyond Kubler-Ross’s five.

**Enthusiastic Involvement.** If I die in a leisurely fashion—that is, after experiencing the five stages listed above—I hope that I can “get into it” and become involved in the process, experiencing what I can, while I can. I hope that eventually it will be the same way with ABET’s criteria—everyone will be enthusiastically involved and doing their best. The winners will be our students, our profession, and, ultimately, society.

Lyle Feisel is engineering dean at SUNY-Binghamton and a past president of the American Society for Engineering Education.
Voice of Experience

Jack Lohmann

There was a time when many of us would have had to stop and think for a moment if asked when our next ABET visit was due. Since the implementation of the Accreditation Board for Engineering and Technology’s Engineering Criteria 2000, everyone now seems to know without hesitation—and to be asking everyone else: “What are you doing to get prepared?” We no longer need to ask that question at Georgia Tech. As one of five engineering colleges piloting Engineering Criteria 2000, we participated in an ABET review during fall 1997. Now that I’m a veteran of the new accreditation system and its outcomes-based assessment requirement, I would like to share some observations about the experience as well as make some suggestions about how to prepare for Engineering Criteria 2000.

Observations

First, I am pleased to report that the new accreditation process is less adversarial than the former one. During a spring workshop for some of the pilot colleges, ABET set a very positive tone about the process. The opportunity to interact with evaluators at this workshop proved reassuring and very helpful, as did the continued interaction that led to the actual visit. Establishing a dialogue between the visiting team and the college prior to the visit benefits all parties.

Second, preparing the documentation was not as onerous a task as anticipated. It’s true EC 2000 gives us greater latitude in how we present information, which in turn requires considerable effort on our part to decide what data to present and how to present it; nevertheless, the overall endeavor was no more time-consuming than before, and in some ways, even less so. For example, schools now can present the ponderous, old “Volume I” as a concise appendix to the program self-studies, which themselves need not be that lengthy.

Third, demonstrating that we had assessment processes in place was not especially difficult, particularly because at Georgia Tech we began to address assessment issues as early as 1992. Demonstrating that we used the assessment results to change the curriculum, however, was not so easy. Changes in academic programs are sometimes the result of information received from different sources, and over a period of time, linking those changes back through an archival “paper trail” was difficult at times. Demonstrating that one has “closed the loop” between assessment results and curricular change is a worthy goal, but it is not necessarily a straightforward process. This is one area that calls for additional thought on everyone’s part.

Suggestions

I have three suggestions for those preparing for their first EC 2000 visit.

1. Examine your school’s current assessment mechanisms, and adapt them
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to EC 2000. I hear a lot of discussion at regional and national meetings about how to establish assessment measures, but at Georgia Tech we decided to focus on improving our existing procedures. We had long been surveying alumni, employers, faculty, and students; conducting exit interviews of graduating students; seeking input from advisory committees; and benchmarking against peer institutions on a variety of measures. These assessment measures fit quite well into EC 2000.

2. Get to know your key constituents and your key academic competition. We defined our key constituents as our students, employers, faculty members, and alumni. We also identified the 12 engineering colleges that are our top competitors as well as the chief competitor for each of our discipline-specific schools. Now we regularly survey our constituents and benchmark against our competitors.

3. Start collecting data now. Don’t worry about having “the perfect” assessment measure. Every assessment measure has some flaw. So just get started. Looking at the information generated by a number of measures, over time, will provide useful insight.

Like it or not, assessment is here to stay. Indeed, at Georgia Tech we are now embarking on assessing our graduate programs. Assessment does take time and effort, but the results can be worthwhile.

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