THE ABET CRITERIA FOR ENGINEERING TECHNOLOGY ARE BROKE. LET'S FIX THEM!

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ABSTRACT
The proposed new ABET criteria for engineering technology[1] have generated much discussion in the engineering technology community. A common concern is that the proposed outcomes-based criteria, without quantitative specifications, cannot maintain the quality of programs as effectively as the existing ABET criteria do. This paper will show that the rationale behind existing criteria is often not clear, and the criteria themselves are vulnerable to inconsistent interpretation. After examining major elements of the existing criteria, this paper will show that they do not provide a reliable basis for determining the quality of graduates from engineering technology programs. It will be suggested that outcomes-based criteria present no more of a threat to quality than do the current criteria, and that the proposed criteria have the potential to improve reliability of the accreditation process by focusing only on factors directly affecting the quality of graduates.

I. NEEDED: A NEW FORM OF CRITERIA

Historically, as the Technology Accreditation Commission (TAC of ABET) encountered new accreditation issues, it amended criteria to address those new issues. However, changes in degree programs occurred more rapidly than the current criteria could be modified under TAC's two-year revision cycle, and it became increasingly clear that the existing criteria were not a suitable framework from which to address new and emerging issues in engineering technology education. With remote delivery of courses, web-based instruction, just-in-time instruction and non-traditional programs becoming increasingly common, TAC realized their criteria document needed more than amendments---it needed a new framework. In 1996, the TAC Criteria Committee was charged to recommend the format and substance for criteria suitable for accrediting engineering technology programs into the long-term future. That committee opted for outcomes-based criteria, the concept of which was endorsed by the TAC in July of 1998.

The Engineering Accreditation Commission (EAC of ABET), having experienced similar problems, had already begun to implement outcomes-based criteria by 1996. Both the new EAC criteria and the proposed TAC criteria were intended to be more compatible with assessment philosophies being used by most universities and regional accrediting agencies. Regional accrediting agencies focus on institutional self-assessment, and their approach to accreditation requires institutions to

a. define their objectives,
b. perform a self-assessment to see how well their objectives and accreditation criteria are met,
c. address the weaknesses found in the self-assessment, and
d. submit to an on-site visitation by the accreditation agency.

Emphasis is on managing assessment and self-improvement, and institutions are accredited based on convincing evidence that they can effectively manage the quality of programs while complying with criteria.

II. IT'S BROKE AND NEEDS FIXED

> "Accreditation bodies - both regional and specialized - have been inclined to emphasize traditional resource measures as proxies for quality. Such traditional measures are often difficult to link to demonstrated student achievement." -- National Commission on the Cost of Higher Education[2].

Much of the anxiety expressed about the proposed ABET criteria for technology stems from their lack of numbers and specificity when compared to the existing criteria. The proposed criteria have been perceived as allowing an institution to do anything it wants: diminishing mathematics and science requirements, dumbing-down courses in general, hiring unqualified faculty, reducing quantity and quality of laboratory classes/facilities, etc. With the current criteria, TAC has operated under the concept that specifying inputs to the educational process would assure quality of the output.

However, the current form of criteria lacks flexibility to accommodate the number of options currently in use for program structure and instructional delivery. Examination of the current criteria will reveal that they

1. over-prescribe in some areas while failing altogether to address equally critical issues,
2. provide for misinterpretation by institutions and accreditation teams,
3. utilize arbitrary criteria which are difficult to correlate to quality of graduates,
4. encourage emphasis on numerical criteria rather than program effectiveness,
5. limit the mechanisms by which an institution can improve its programs and
6. fail to adequately convey the intent of important criteria elements.

III. THE DILEMMA OF CONTINUOUS IMPROVEMENT

> "Accreditation seeks not only to judge and assure quality and integrity, but to promote improvement through continuous self-study and evaluation." -- National Commission on the Cost of Higher Education[2]

Historically, TAC has evaluated programs by assessing what existed at the institution at the time of the visit---the snapshot approach---and comparing that to criteria. In determining an accreditation action for a college visited in the fall, TAC has considered only corrective measures which have been completed by the time of the annual ABET Commissions meetings in the following July. Under this snapshot-in-time approach, there is little to insure that program quality at a given institution is maintained between accreditation cycles. This is especially critical if the cycle is longer than the time required for students to complete a degree.

Although TAC does not formally consider a program's long-range plans when determining accreditation action, ABET criteria state

> V.A.2. "Programs must have plans for continuous improvement. The visiting team will be looking for evidence which demonstrates implementation of continuous improvement processes and procedures for each program."[3]

Criteria do not give guidance to institutions or accreditation teams on what constitutes acceptable evidence of a continuous improvement plan, or on what elements of the degree program must be addressed in the plan, although both issues are critical to insuring the long-term health of programs. As a result, TAC does not have reliable or consistent information on continuous improvement plans by programs being accredited.

With a six-year accreditation cycle, TAC cannot be reasonably assured that quality is being maintained between accreditation visits unless institutions a) continuously supply ABET with details of changes

which must be submitted to TAC for approval, or b) have in place a credible continuous assessment-improvement plan which can be trusted to manage change between accreditation visits.

ABET criteria section IV.D. mandates the former approach:

> IV.D.1. " It is the obligation of the administration officer responsible. . . to notify ABET of any changes in content and/or title of curriculum during the period of accreditation and to submit catalog revisions of accredited programs to ABET when the catalog revisions are published."[3]

> IV.D.2. "TAC of ABET must be kept informed of program terminations and other significant changes in programs, staff, facilities, organization, enrollment, and other pertinent factors.. . ." [3]

The need for these two criteria underscores the inherent unworkability of the current criteria. In order to make its criteria work with the "snapshot" approach used by accreditation teams, TAC must maintain continuous vigil over programs between accreditation visits. In reality, this doesn't work; institutions who have been accredited by ABET already know that IV.D.1. & 2. are not enforced. However, the presence of these two criteria can be intimidating to programs trying to decide on whether the hassle of accreditation is worth the benefit. The absence of these requirements, unenforceable as they are, would make the criteria appear "toothless." In an operational sense, the criteria in their current form really are toothless in the absence of a mechanism for assessing between-visit changes in programs.

The juxtaposition of ABET criteria IV.D.1. & 2. (must notify ABET of all changes) and VA.2. (must have a plan of continuous improvement) creates a Catch-22: if the programs at an institution are continuously improving, then they are continuously changing, and criteria state they must be continuously reporting those changes to ABET. This continuous reporting is no incentive to institutions to develop an active continuous improvement plan. Furthermore, if TAC feels a program has an acceptable continuous improvement plan, why is all this continuous reporting necessary? Besides, does ABET really want to get a report and does TAC really want to have to approve it every every time a program makes "any changes in content or title of curriculum?" Enforcement of these criteria would place an unrealistic burden on the institution and an impossible workload on ABET. These criteria give the appearance of insuring program quality between accreditation visits; in reality they are unworkable and could be only selectively enforced, exacerbating institutional perceptions that the process lacks consistency from one accreditation visit to the next.

IV. CURRICULAR CRITERIA

In the existing criteria, subject matter is specified either by topic or by minimum number of course credits, although neither style of specification gives good insight into the level of performance expected of graduates.

Use of numerical specifications in curricular criteria not only fails to convey the expected academic rigor, but also restricts program flexibility in improving instruction and provides the uncertainty which allows inconsistent interpretation. Although the numeric criteria reduce curricular flexibility, TAC purports to encourage innovation in

> V.B.3. "ABET encourages innovative or novel program arrangements. Non-traditional programs will be evaluated against the above criteria to ascertain that the programs satisfy the intent of the minimums established."[3]

Criterion V.B.3. gives the appearance of making criteria more flexible, and it refers to the "intent of the minimums," but the criteria providing those numerical minima do not provide clear statements of intent. Programs cannot be innovative (and still maintain ABET accreditation) without a clear understanding of the levels of competency which TAC expects of graduates.

Current criteria for mathematics in baccalaureate degrees provide a case in point:

> V.B.2.c. ". . .The mathematics component must include at least 12 semester hours or 18 quarter hours in areas specified in section V.C.4.c. . . .",[3]
>
> V.C.4.c.1:". . .Competence in the application of algebra and trigonometry to problem solving must be demonstrated in appropriate technical courses."[3]
>
> V.C.4.c.2. "In baccalaureate programs, particularly, the study of the concepts of calculus must be included in the program to ensure that students are professionally literate. Upper-level technical courses must include applications of calculus in technical problem solving where appropriate in the curriculum."[3]

Reference to "the concepts of calculus" does not indicate what academic level is expected. Hypothetically, an institution could have 12 semester hours of algebra and trigonometry, include an introduction to "the concepts of calculus" in one of the courses, and have a strong argument that the criteria are met. Taken collectively, these three criteria imply a program can use whatever level of calculus it wishes, but whatever level is chosen must be used in the upper level technical courses.

In applying criterion V.C.4.c.2. (upper-level technical courses must include application of calculus), it is not clear who judges where it is "appropriate" to apply mathematics in technical problem solving. This criterion is vulnerable to subjective interpretation, and it provides little guidance to institutions in anticipating what the accreditation team will expect to see.

Mathematics requirements for specific majors can be clarified by professional societies through program criteria. For example, program criterion VI.F.2.c.(2) from ASCE for civil engineering technology programs is an outcomes-based criterion and contributes substantially to clarifying general criteria:

> VI.F.2.c.(2) "Baccalaureate degree programs in civil engineering technology must ensure that a student understands and is able to use algebra, trigonometry, analytic geometry, and applied differential and integral calculus."[3]

This criterion, taken alone, could replace all the mathematics criteria in V.B.2.c. and V.C.4.c.; it could do so with less ambiguity, with a clearer statement of intent and without specifying any credit hours whatsoever.

Some program criteria not only do not clarify the intent, but add their own elements of confusion. Does citing specific topics (i.e., algebra, trigonometry, concepts of calculus) imply separate courses in each topic? It is not clear in the criteria, and this issue is inconsistently interpreted, not only by accreditation team members, but also by professional societies who submit program criteria. Consider VI.J.2.c.(2), from IEEE for electrical/electronics engineering technology:

> VI.J.2.c.(2) "A minimum sequence in mathematics is college-level algebra, trigonometry, and an introduction to calculus. Baccalaureate programs must include differential/integral calculus, and instruction in applied differential equations is strongly encouraged. Linear programming, numerical methods, and probability/statistics are other appropriate electives."[3]

Although the first sentence seems to implies individual courses ("a minimum sequence") in each topic, it doesn't really say so. In the second sentence reference is made to "instruction in applied differential equations. . .," which appears to refer to topics rather than courses. However, in the last sentence it refers to specific subject areas as "appropriate electives," implying individual courses. Is this criterion to be interpreted as requiring a separate course in each of the topics ?

Program criteria for mechanical engineering technology from ASME state:

> VI.N.2.c.(2) "Mathematics must include topics in algebra and trigonometry and at least an introduction to calculus for the associate degree. A second in calculus is required for a bachelor's degree."[3]

In the first sentence, this criterion clearly refers to topics, but the second sentence presumably refers to a second calculus course. Does this criterion require separate courses in each topic?

There are other problems associated with criteria which specify a fixed number of credit hours for

particular subject areas. For example, how should an institution interpret criterion V.B.2.c. (12 credits of mathematics required) in the case of students who transfer from engineering with their only mathematics credits being eight semester hours of calculus? It appears the current criteria require these students to take four more hours of mathematics when they already have credit for the highest level of mathematics required by accreditation criteria. To comply with these numerical criteria, a student would have to either a) take advanced math beyond what colleagues are required to take or b) take a lower level of math than the credit already granted. Is either scenario logical?

Although numerical criteria can be useful as a rough guide, performance-based criteria are clearly needed to reduce ambiguity and provide institutions a clear intent on which to base program objectives and innovation.

V. NUMBERS VERSUS OBJECTIVES

> "Then shalt thou count to three. No more. No less. Three shalt be the number thou shalt count, and the number of the counting shall be three. Four shalt thou not count, nor either count thou two, excepting that thou then proceed to three. Five is right out."-- Monty Python and the Quest for the Holy Grail [4]

The magnitude of a given quantitative specification in ABET criteria is difficult to correlate to measurable performance of graduates. For example, is it demonstrable that technology graduates with 11 credits of mathematics are inferior to graduates with 12 credits of mathematics? Would the effect on performance by graduates be predictable and measurable if the ABET criteria for mathematics were reduced to 11 or increased to 13 credits? The variation in academic level between accredited programs likely has a greater effect on graduates than would TAC's increasing or reducing mathematics requirements by one (or even more) credit hour. If that is true, then these criteria are arbitrary and cannot be assessed or refined through a process of continuous improvement. Furthermore, these numerical criteria without measurable objectives are clearly impediments to curricular innovation.

What assurance is offered by the specification "12 credit hours of mathematics" when it contains neither an indication of academic level nor indication of expected student competency. We teach our students not to use more significant figures in their computations than an experimental measurement justifies, but in the current TAC criteria, there are two-significant-figure specifications, the effects of which can't even be objectively determined, let alone quantified and assessed.

VI. FACULTY CRITERIA

Although the proposed new criteria are largely based on outcomes assessment, faculty criteria in that document[1] are essentially identical to those in the existing ABET criteria. Several elements of both the current and proposed criteria for faculty are ambiguous and arbitrary.

<u>Number of Faculty</u>

Current criteria give a rationale and then specify the minimum number of faculty in accreditable programs:

> V.F.4. "The number of faculty members must be great enough to provide a breadth of perspective, program continuity and proper frequency of course offerings."[3]
>
> V.F.4.b."Each baccalaureate degree program must have at least two faculty members with basic credentials whose primary commitment is to the program and a total of at least three FTE faculty members."[3]

V.F.4. is a criterion with measurable outcomes, and its intent seems clear enough -- why shouldn't this statement, alone, suffice for determining the number of faculty in a program? This criterion implies that the only guarantee of breadth of perspective, continuity and course frequency is the number of faculty members in the program. Furthermore, the combination of V.F.4 and V.F.4.b. create a fundamental

philosophical conflict. On one hand, a program could be providing proper "breadth of perspective, program continuity and proper frequency of course offerings" with 2.5 FTE. On the other hand, the program could have 4.0 FTE of faculty and still not provide the proper breadth, continuity and course offerings. Is a program to choose whether its goal is to "provide breadth. . .etc." or whether its goal is to meet the number of faculty specified in the criteria?

Flexibility appears to be provided by

> V.F.4.e. "If an institution convincingly demonstrates that breadth of perspective, program continuity and proper frequency of course offerings are provided by alternate means, exceptions for items a. through c. may be considered."[3]

However, an examination of the wording reveals an internal lack of logic. Why does this criterion contain the wording "may be considered"? If the institution "convincingly demonstrates" it is meeting the intent of the criterion, why shouldn't the criteria say "will be granted?" This type of wording only reinforces (or spawns) institutional perceptions of inconsistency within the accreditation process.

Validity of these faculty criteria depends on the ability to correlate the numerical specification to quality of graduates--is this measurable? If 2.5 FTEs is inadequate, then there should be definable and measurable benefits attributable to the additional 0.5 faculty required to meet criteria. Logically, why should a program with 2.5 FTE of very effective faculty producing well-qualified graduates be cited for this weakness (or be denied accreditation) when there is no program shortcoming attributable to the 0.5 FTE of missing faculty? This is an arbitrary and invalid criterion to which assessment and continuous improvement cannot be applied.

<u>Basic Credentials</u>

The ABET criteria specify three basic credentials for faculty: academic degree level, major field of academic degree (very broadly defined), and a number of years of industrial experience. However, the criteria only vaguely describe the rationale for those three items:

> V.F.1. ". . . Basic credentials are prescribed to assure the program is appropriately quantitative in nature and includes proper engineering and industrial emphases. . . ."[3],

Criteria do not provide guidance to the institutions on the expected effect on graduates. Although the qualities stated in V.F.1. are, without doubt, desirable program characteristics, the criteria illogically imply that faculty credentials are the only insurances (or sources) of those program characteristics.

Having industrial experience does not mean faculty can effectively translate that experience into worthwhile classroom instruction. Likewise, the lack of industrial employment does not preclude a faculty member from having other experiences from which to effectively inject the industry flavor into a curriculum. Furthermore, the number of years of industrial experience is secondary to the expressed intent of the criteria---in engineering technology, a faculty member with a half-year of experience acquired over the past two summers is more industrially up-to-date than the faculty member with 10 years of industrial experience which ended 20 years ago. It is important to note that, although these criteria rigidly mandate three years of industrial experience, they do not even require the experience to be technologically current.

Criteria require the faculty to have a minimum of three years of "relevant industrial experience," but do not give guidance on what is meant by "relevant" or "industrial"or "experience." One might assume "relevant" means relevant to the field of instruction. However, since criteria define the appropriate degree as being in any field of engineering technology or engineering (doesn't have to be in the field being taught), this would seem to imply that any industrial experience from any engineering or technical field is "relevant." What does "industrial" mean, for example, in civil engineering technology? Government

service? Engineering consulting? Military experience? Manufacturing? Maintenance? Teaching in industry? Research? What criterion gives guidance on determining what is "relevant industrial experience?"

The criteria are also not clear on what is meant by "experience," although this has consistently been interpreted by TAC and the accreditation teams as being synonymous with "employment." If this is really the intent, why don't the criteria say so? There is no clear interpretation of whether part-time consulting meets the intent of this criterion, so the value of this type professional experience, which is often difficult to document, is inconsistently represented by institutions and inconsistently interpreted by accreditation teams. Likewise, the issue of university research for industrial clients, while industrial "experience," is not normally interpreted by accreditation teams as meeting these criteria. If a faculty member has three years of non-academic technical employment of some kind, no matter how long ago or in what technical field, it has generally been accepted in meeting the experience requirement.

Clearly, the criterion for industrial experience is so vague and has been interpreted so inconsistently by program evaluators, institutions, team chairs, and the TAC itself, that it is a superfluous criterion with little or no validity in assessing the quality of a degree program.

Although faculty for baccalaureate programs are supposed to have at least a masters degree, there are related issues which this criterion fails to address at all. Criteria state that faculty must have a masters degree in engineering, engineering technology or closely related area—however, criteria do not say those degrees in engineering or technology have to be in the same field as the faculty member is teaching. As clarified in "Closely-related" in these criteria refers to non-technical degrees such as a degrees in the physical sciences.

Under current criteria, a faculty member teaching baccalaureate Civil Engineering Technology would meet basic credentials with BS and MS in any field of engineering or engineering technology, but would not meet basic credentials with a BSCE and PE in Civil Engineering. While the fields of electrical, mechanical and industrial engineering technologies may be closely linked in manufacturing industries and may well be able to utilize cross-discipline faculty, the value of a faculty masters degree in, say, electrical engineering is not readily apparent for a civil engineering technology program.

ABET criteria also define the proportion of faculty which must have basic credentials:

> V.F.5. ". . . For a baccalaureate degree program at least two-thirds of the FTE faculty must have basic credentials."[3]

Can it be shown that baccalaureate programs with two-thirds their faculty having basic credentials are consistently more effective than programs with half the faculty having basic credentials? If not, then this specification is invalid as a measure of program quality, and it, too, is unassessable in a program of continuous improvement.

The issue of faculty credentials is further confused by

> V.F.2. "In exceptional cases there may be technical faculty members who satisfy the intent of the above minimums without literally satisfying the criteria. TAC of ABET may recognize these exceptions if the institution convincingly demonstrates the equivalence."[3]

This criterion appears to insert flexibility by giving the institution an option to utilize alternate faculty credentials and "demonstrates the equivalence." Fine -- but demonstrate the equivalence of what?

a) If ABET's objective is to assess the degree programs, then an institution could logically assume that the "equivalence" would refer to program characteristics described in V.F.1. (quantitative program, proper engineering and industrial emphases.) There may, indeed, be several methods of demonstrating that

engineering and industrial orientations are effectively integrated into a curriculum, but these are program characteristics, not faculty characteristics. Where is the connection to competencies of graduates?

b) If ABET's criteria are to be taken literally (section V.F. of the criteria is entitled "Faculty"), an institution might assume "the equivalence" refers to demonstrating that faculty have the "equivalence" of a master's degree, or that faculty have the equivalence of industrial experience, neither of which requires the institution to document any impact of these "equivalences" on graduates of the program. This line of reasoning involves faculty characteristics, not program characteristics. Where is the connection to competencies of graduates?

Institutions should be able to implement alternative means of insuring their graduates have adequate exposure to industrial techniques without having to rely on the personal industrial experience of their faculty. Why should a program with a mandatory co-op program be required to have faculty with the same industrial experience as a program without co-op? What about a program which regularly collaborates with industry to provide classroom instructors from industry--why should their full-time faculty have to meet the same requirement for industrial experience as a program with no such industry involvement in the classroom?

While faculty and curriculum are all necessary means to accomplish the goal of producing graduates, criteria which focus only on curricular elements or only on faculty characteristics are not useful in determining the success of an educational program. Credible criteria must be structured so there is no doubt that the intent is to assess characteristics of graduates.

> "The commission recommends that accrediting associations reshape existing standards and review processes to include a greater emphasis on measures of effectiveness -- especially student achievement-- and less emphasis on resources." -- National Commission on the Cost of Higher Education[2]

VII. CONCLUSIONS

1. Taken as a whole, the current criteria contain a high degree of uncertainty and latitude for interpretation because there is little emphasis on characteristics of graduates of the programs being accredited.

2. Numerical specifications for faculty and curriculum characteristics are not reliable measures of program effectiveness. The numerical criteria frequently fail to a) adequately convey their intent or b) present an assessible characteristics competencies of graduates.

3. As a result of conclusions 1. and 2. , current criteria are difficult or impossible to adapt to non-traditional program delivery, curricula, pedagogy and faculty.

4. The magnitudes of most numerical specifications in the current criteria cannot be related to the quality of graduates. In engineering terminology, these criteria are very precise but highly inaccurate.

5. Accreditation criteria should form the basis for a program's continuous improvement plan; however, although current criteria mandate continuous improvement plans for all programs, those criteria provide little guidance as to what is expected.

6. Although TAC requires all degree programs to have plans for continuous improvement, arbitrary numerical specifications and the uncertainty of intent in the current criteria preclude that criteria, itself,

from being the beneficiary of an effective continuous improvement plan.

VIII. RECOMMENDATIONS

1. Accreditation criteria must emphasize desirable outcomes in terms of graduate competencies.

2. In order to be a valid measure of program effectiveness, every element of criteria must present an assessible characteristic of graduates.

3. If quantitative information must be used to clarify the intent of criteria, then those quantities should be used only in an advisory capacity, not as criteria. Numerical specifications should be clearly secondary to criteria specifying characteristics of graduates.

4. Criteria themselves can be assessed and continuously improved Criteria elements must be written so their effects on programs are identifiable and measurable, permitting the.

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