ABET ENGINEERING CRITERIA 2000 – A TOOL FOR PROMOTING CURRICULUM DEVELOPMENT AND EFFECTIVE PROGRAM ADMINISTRATION.

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Abstract *– The introduction of Engineering Criteria 2000 (EC2K) in the mid-1990s represented a major change in the approach to accreditation by the ABET. While most institutions have been challenged by the new criteria, some have embraced them, and used them to promote curriculum reform. There is no doubt that this new paradigm for accreditation demands a far greater contribution by engineering faculty and program administrators. Successful accreditation now requires that both work collaboratively, because under EC2K all facets of program operations have to be subjected to continuous improvement.*

The paper describes how the new criteria can support departmental activities such as student advisement, curriculum re-design, facilities enhancement, faculty development and the other aspects of program administration. The author provides some insight (based on his own experiences) for a successful accreditation visit.

Index Terms – ABET, Engineering Criteria 2000, Program Administration

The opinions presented in this paper are those of the author, are given in light of his own experiences, and do not necessarily represent the opinions or policies of the ABET.

Conversations with teaching faculty on the subject of ABET Engineering Criteria 2000 generally center around criteria 3 (a-k) and the outcomes assessment requirements. However EC2000 is much broader in its requirements and, in fact, comprises criteria 1 through 7 plus the additional program-specific criterion 8. The announcement of Engineering Criteria 2000 heralded a move away from the batch processing approach to accreditation that was required under the previous Engineering Topics criteria, to a new continuous improvement modality. Continuous improvement is the goal of EC2000 – in **all** of the areas defined by the criteria. The eight criteria are: 1. Students; 2. Program Educational Objectives; 3. Program Outcomes and Assessment; 4. Professional Component; 5. Faculty; 6. Facilities; 7. Institutional Support and Financial Resources and 8 Program Criteria. These topics cover virtually all of the operational activities relating to the academic program within a department, and can be used in identifying strategic planning issues, and managing and developing an academic department.

The simplest way to proceed is to take a systems approach in which all parts of the academic unit's operations are reviewed. This approach will be discussed by first considering each of the eight ABET EC2000 criteria, identifying and raising some of the issues associated with each one, and hopefully, providing some useful pointers that will help with pre-visit preparations. Following this, the departmental implications will be considered. The reader is referred to the ABET document Engineering Criteria 2000 [1].

CRITERION 1: STUDENTS

The italicized text used in the EC2000 publication, states clearly the advising standard required for an accreditation visit to be successful. Some of the questions that come to the program evaluators mind, follow. Firstly, are faculty actively engaged in the process of advising engineering students and are they (particularly if they are new hires) given any guidance regarding their advising responsibilities? Is the advising meaningful or is it undertaken only when time permits? Has there been more than an isolated case of a student being unable to graduate due to courses being unavailable to students? Have course substitutions been made to "accommodate" students who have been unable to take a prescribed course? What are the reasons that courses are unavailable? What is the typical advising load and is the advising load reasonably distributed throughout the departmental faculty? Can advising be effective if an advisor has a large number of advisees? What level of preparation is provided to members of faculty so that they are effective advisors? What training/support is provided to academic advisors through the university's office of student affairs so that they are able to identify students who require professional counseling?

Implications

If a department chair can provide the good answers to these questions then it is likely that sufficient thought and effort has been put into providing an environment capable of guiding the student to an on-time graduation. Very often this very important aspect of faculty responsibility has to be learned in an ad-hoc manner from colleagues. The departmental responsibility for advising is coupled to the institutional responsibility to keep accurate academic records. That is, there should be an appropriate level of communications between the faculty member, the

department and the registrar's office so that all students know the graduation requirements for their program of study and typically receive timely notification from the registrar (particularly during the senior year) so that there are no last minute surprises. This often is accomplished by two or perhaps three check points during the senior year at which time the students official record is checked to verify that graduation can occur on time.

CRITERION 2: PROGRAM EDUCATIONAL OBJECTIVES

Program Educational Objectives (PEOs) have been the primary focus of engineering faculty members because it is virtually impossible to embark upon any assessment activity unless these objectives (along with their associated outcomes) have been discussed and defined. The discussion of PEOs can be a truly worthwhile experience if those involved have a sincere interest in implementing a continuous improvement plan. The discussion takes the faculty upon a journey of discovery! The development of the objectives and outcomes creates an environment in which faculty search for the true purpose of their educational endeavors, and often percolates right down to the course level. By taking a systems view of the educational process, faculty discussion should lead to significant program improvement.

An important part of the process is the requirement to publish the results of this discussion so that potential students are able to determine the suitability of the program in the context of their own career goals. It is a requirement for truthful advertising! It is important that the PEOs are consistent with the mission of the institution. For this reason, the self-study document will often include the institutional mission statement followed by the department's PEOs to make the connection. This saves the program evaluator from having to search other institutional documents in order to verify the commonality of purpose. The program evaluator may inquire about how and when the institutional mission statement was derived and who was involved.

Implications

It is critically important that the PEOs reflect the needs of program stakeholders. (ABET uses the term constituencies, but the term stakeholder better describes the relationship of the community of persons and organizations with whom the institution interacts.) In the author's experience, the stakeholder groups typically include employers of program graduates, parents, students, graduate or professional schools, organizations hiring co-op students or interns, and the senior administration of the institution. The process of developing the PEOs usually originates within the institution, and results in a first draft that serves as a straw man. This document usually then is the focus of subsequent discussions during which representatives of the stakeholder groups are active participants. Revisions to the PEOs then occur until an acceptable set is derived. It should be expected that from time to time, opportunities for PEO revision and updating occur on an ongoing basis (perhaps bi-annually). It is inappropriate for program evaluators to critique PEOs.

The final element of this criterion is the establishment of an on-going process that permits the faculty to determine how well the organization is meeting the PEOs. Completion of one (and preferably two) complete cycles – constitutes closing the loop. However, it should be emphasized that the renowned ABET loop diagram, really has two loops. The two-loop diagram has an external (left-hand) loop which requires the on-going involvement of the stakeholders and the periodic reviewing/updating of the PEOs referred to above; while the internal (right-hand) loop requires collection and review of relevant data followed by action.

A mature program may also exhibit the application of the continuous improvement cycle to its own process. That is, has the process, which has been developed by the faculty, produced beneficial results and can the process itself be further improved? A program can demonstrate this level of maturity through refinements to its internal and external practices and procedures. It may be, in the early years of establishing such a system, that target goals representing adequate performance are set too low (or unattainably high). Continuous improvement may also indicate that a particular assessment parameter has been achieved and therefore no longer requires measurement. It is at this time that attention should be turned to another parameter, which then can be focused on, until it too has been improved to an acceptable level.

CRITERION 3: PROGRAM OUTCOMES AND ASSESSMENT

Much has been written in the educational literature about criterion 3. It would be foolish even to try to summarize that body of knowledge here. However, it is appropriate to note the strong interrelationship between criterion 2 and criterion 3. Firstly, any set of PEOs developed by the faculty must include all of criterion 3a – k! These are defined as the ABET minimum set. They were derived through extensive discussion between ABET and the engineering community, including the professional institutions. Engineering employers were also involved

Most program self-studies show that its PEOs meet or exceed ABET requirements through a correlation matrix which in which the PEOs are mapped against the ABET

criterion 3a-k. Once the PEOs have been shown to meet or exceed ABET 3a-k, a strong program may proceed to document its progress in terms of its own PEOs and outcomes rather than the minimal set defined by ABET. A word of caution is appropriate at this point however, since program evaluators are trained to look for a – k! Also be aware that, program evaluators are told to be particularly inquisitive when a program has adopted ABET criterion 3a-k unchanged. This is viewed as a (weak) shortcut approach in which the necessary faculty discussion of PEOs may not have taken place.

It is reasonable to expect that the ABET 3 a-k set will change over time as ABET interacts with its constituencies, in much the same way that program faculty members interact periodically with its stakeholders.

Implications

Criterion 3 is typically the focus of faculty attention – namely the assessment of student educational outcomes – but for continuous improvement to be thoroughly implemented, the assessment process should be pervasive and therefore also applied to criteria 1, 4, 5, 6, 7 and 8. Note that criterion 8 relates to a multiplicity of *program criteria*, which are determined by the professional institutions. While the definition of the program criteria is left to these bodies, it is the responsibility of the faculty to insure that each program meets the expectations of the professional organizations and that students' abilities in this regard are continuously improving. Therefore, to guarantee a successful accreditation outcome, a program should expect to demonstrate that a continuous improvement process is applied to student advising, the professional component of the program, the faculty, the institutional resources and to program criteria. That is, the collection of data is followed by a decision making process which results in action(s) which insure continuous program improvement.

CRITERION 4: PROFESSIONAL COMPONENT

Authors of the self-study should read criterion 4 very carefully in order to understand its intent. Specific courses are not prescribed, but it is the responsibility of the faculty to insure that the program prepares students for professional practice. Programs focusing on preparing students for graduate study are not absolved from meeting this requirement.

Implications

The major focus of this criterion is the requirement that students participate in a major (culminating) ***design*** experience. Better still the project should be interdisciplinary (although this does not mandate an interdepartmental project), be team based (prepared for engineering practice), because most engineers now work in teams. I believe that it is difficult to meet these realism requirements without the project being client-based, and of a full year's duration. Put another way, it is much more difficult for a program evaluator to cite a deficiency, weakness or concern when the experience involves a yearlong, team-based, client-oriented design project. For institutions organized on a quarter-based calendar, it is difficult, in a one or two quarter long, partitioned project (project definition in fall quarter, project work in winter quarter) to provide enough time for students to work under realistic constraints. The time constraints of a ten-week project mandate that students undertake fairly straightforward projects because there is no time for mistakes, or for delays (or to try alternatives), and complete the project on time.

Some concern has been voiced about the word *interdisciplinary*. My interpretation is that, because the nature of engineering work has become considerably more complex in recent years, it is necessary for the student to experience the benefits of working as a member of a team. A team is a group of individuals each with his/her own skills, without which the team would be incomplete. Using this definition, it therefore is possible to have interdisciplinary projects *within* a department.

Having focused initial comments upon the project portion of criterion 4, it is essential that the other components are not ignored. The self-study author should explicitly state how the parenthetical components, (in the EC2000 document [1]), are met by the program being evaluated. List the courses that form the one-year of mathematics, making sure that the definition of *one year* is understood and met.

List the courses that contribute to the one and one half years of engineering topics, making sure that the course numbers and titles agree with those given in, the Basic Level Curriculum as stated in Table 1 of the self study. Similarly, for the general education component which, under EC2000, has been considerably relaxed. The department (or college) should describe how the general education component was determined and who was involved in the process. External stakeholders should have been involved! There should also be evidence of some internal, institute-wide, dialog in which the various colleges have discussed an institutional general education requirement. Otherwise, it will be difficult to show how college level requirements mesh with the institutional objectives and outcomes.

CRITERION 5: FACULTY

The opening sentence (describing this criterion [1]) is very clear, and indicates the weight placed upon faculty credentials. It is essential that the self-study show that a

sufficient number of faculty members with appropriate expertise, contribute to the program. Faculty credentials (academic and professional), years of experience, and level of professional activity are all required in Table 4 - Faculty Analysis. EC2000, unlike previous accreditation criteria, does not state a minimum number of faculty members. (Under earlier criteria the acceptable number was "at least four"). A high faculty turnover may point to poor facilities, inadequate institutional support, high teaching loads, inadequate benefits packages, or any number of other factors, and a diligent program evaluator will want to investigate the reasons. Retirements or resignations need not be a reason for concern, especially if these are handled with searches that result in the hiring of appropriately credentialed replacements. Likewise, the employment of large numbers of adjunct faculty members need not necessarily be a reason for concern.

Implications

If continuous improvement of the faculty is to be demonstrated, the program evaluator would hope to see an appropriate level of professional activity. Quite a wide variety of activities may be used to demonstrate professional development, depending upon the nature of the institution. Research-oriented institutions may have funding and/or publication targets while teaching-oriented institutions interpret this requirement more broadly. The ability of faculty members is determined in part by the availability of institutional funds which can be verified though Tables 11-5 Support Expenditures, and Table II-7 Faculty Salary Data, in Appendix II of the self-study.

How does the department validate that the quality of the faculty is continuously improving? Who is involved in the hiring process? Is this purely an internal process? Does the faculty ask students to provide an opinion? How are these various inputs handled? It is not part of the function of the program evaluator to critique promotion or tenure processes, however, a stable and involved faculty is essential if a program is to continuously improve. For this reason the data in the self-study table will be carefully reviewed in conjunction with a determination at the time of the visit of the state of faculty morale.

CRITERION 6: FACILITIES

The highest cost in most educational programs relates to the human resource; faculty, technical, and clerical support staff. Usually the next highest cost is that of the teaching facilities, and associated equipment and computers. The physical facilities in themselves say a great deal, as does the age and state of repair of equipment and computers.

It is essential that the institution demonstrate that adequate resources are being directed towards the on-going maintenance of the infrastructure and the equipment therein. Is there a plan in place that insures that equipment is replaced on a regular basis and how is the adequacy of support evaluated? Does the program attempt to continuously upgrade its laboratory and teaching facilities? Who is responsible for the laboratories, the equipment in them, the computing facilities and network infrastructure? How often is software upgraded and, are there sufficient copies/licenses to meet student demand? The self-study should address the issue of institutional support in criterion 7. Large one-time investments in computers, instrumentation, and other technology without a concomitant increase in the funds to support the capital cost, may be an issue pursued by the team chair with senior administrators.

Implications

In the past the absence of a functional "laboratory plan" would immediately raise a flag. Although EC2000 does not specifically require that one be in place, it is difficult to provide a convincing case for continuous improvement if some long-term strategy is not evident!

Some institutions are contemplating (and beginning) the implementation of a ubiquitous computing model in which each student owns a laptop computer. Others continue to retain the fixed station model. There are many hidden factors associated with requiring students to own laptops (but space considerations don't allow them to be discussed here), and a common pitfall is to underestimate the level of support required to make such a program a success. Some institutions have invested in infrastructure to accommodate new learning methodologies – active learning, cooperative learning, use of multi-media etc. – with the expectation that these new environments are a panacea. Not only are these new spaces expensive, they may require technician support (when a variety of technology is employed) and there will be enhanced maintenance costs which are often not reflected by increased departmental maintenance budgets. Data on equipment expenditures provide part of the picture but much more is learned at the time of the site visit.

The role and abilities of support staff in maintaining equipment and computers can mean that properly maintained equipment can be adequate for a programs needs whereas newer poorly maintained equipment is not. A visit will progress smoothly if there is evidence that equipment maintenance is taken seriously, purchasing of new equipment is monitored and the adequacy of equipment and computers for instruction is periodically reviewed. This information should then be used to prioritize purchases, particularly in environments where funding levels are low and/or irregular.

A similar situation exists with regard to the physical infrastructure. Students who are being prepared for careers in the professional workplace, rightly expect to be trained in an environment that provides comparable facilities. Additionally, it is not unreasonable to expect that a temperature- and humidity-controlled environment which is well lit and provides adequate seating, tables and workbenches, and which conforms to a "professional" standard, be made available to engineering undergraduates. Apart from the discomfort (to humans) of high humidity and temperatures that are too hot or too cold, this environment is not good for equipment, or computers. A well-maintained building, which provides well lit, clean working spaces, does much to provide the accreditation team with a good first impression.

CRITERION 7: INSTITUTIONAL SUPPORT AND FINANCIAL RESOURCES

Departmental operations are funded from the departmental budget, which usually, is determined annually by the university senior administration. Both components are reviewed and the program evaluator will want to ascertain that the institution has an on-going commitment to engineering programs. This will generally be demonstrated by an appropriate level of funding for program (departmental) budgets both to equipment, computers, etc. but also to faculty development through the professional development or travel line item.

Implications

Does the department have adequate opportunity to request funding for departmental (program) operations? Have requests been given fair and equal consideration compared to those made by other departments/colleges? Does the method of distributing finds within the organization disadvantage the college of engineering, or does historical data show that engineering is receiving funding at an appropriate level. These discussions generally occur between the team chair and members of the senior administration. However, concerns about these issues may be initiated by the program evaluator and carried forward by the team chair after discussion by the team.

CRITERION 8: PROGRAM CRITERIA

It is important to clearly identify in the self-study document, the individual courses that are used to meet the criterion. If curriculum requirements are met through material taught as part of one or more courses, they should be clearly identified. If practical applications are required, identify the course(s) and give brief descriptions of them so as to leave no doubt that the requirement has been met. This should be further documented through examples of student work.

Implications

As ABET continues to interact with its stakeholders, the EC2K criteria can be expected to change. It is incumbent upon us all as members of the engineering profession, to be a part of the process when called upon to do so.

THE SITE VISIT

The extra requirements of EC2K have made preparation for the visit more work for all involved. Certainly the faculty has many hours of preparation associated with the assessment of student outcomes. Authors of the self-study should receive the most recent copy of the Self Study Instructions [2] from ABET. It is important to read and follow them when writing the self-study document! Also, the program evaluator has considerably more material to review – university publications, catalogs, transcripts and the self-study document itself. Most of this can be done using the hard copy that has to be supplied by the institution. But, at the beginning of the 21st century shouldn't we be making more of an effort to conserve our natural resources and use electronic communications for this purpose? Certainly student work could be made available (securely) via the Internet, and this would enable the program evaluator to accomplish this prior to attending the university.

Most program evaluators prepare their report prior to the visit so that, under the time constraints of the site visit, they only have to edit it into its final form. While the report reflects the evaluator's opinions after reading the self-study, some programs augment that document with supplemental materials, which are presented to the team when they arrive on campus. Some developments, actions or activities, occur after submitting the self-study, and so have to be submitted at the beginning of the visit. The schedule of activities for the site visit is already very tight, and my experience has been that while this material is reviewed, it is preferable to keep these materials to a minimum. The main reason for trying to minimize them, is because each program evaluator also has other responsibilities during the visit. Not only does s/he have responsibility for the program of study, but also for reviewing one of the support areas. This may be the library, support departments, or the computing center etc., etc.

Most program evaluators establish contact with the department chair prior to the visit. The conversation between the program evaluator and the department chair provides some insight (based upon initial impressions gained from the self-study) prior to the site visit. This provides an opportunity for the department to understand (and to be prepared to respond to) these comments, when the team arrives on campus. The evaluator may ask for clarification of parts of the report or for additional data. Timely response

to these requests can make the actual visit run more smoothly and be less stressful. While the evaluator arrives on campus with initial impressions, the actual outcome of the visit depends upon his/her findings at the time of the visit. My own initial evaluations have been confirmed, and on the other hand been changed radically, by the site visit.

The culmination of the visit is an exit interview, which is usually held in the office of the president of the university. It is conducted under a fairly rigid set of guidelines, by the team chair. Preliminary reports of the various program evaluators are read from prepared statements, which have been discussed by all team members prior to the meeting. It is important that the exit interview identify ***ALL*** the concerns, weaknesses and deficiencies that have been identified by each program evaluator. The team chair will make comments on institutional level issues, while each program evaluator discusses an individual program. As a departmental chair I found it essential to take notes, because no printed copy of the remarks are provided by the team. It is important to understand that the draft report (which will eventually be sent to the institution) cannot contain any concerns, weaknesses or deficiencies that have not already been identified in the exit interview. However, it my be possible during due process to have some of them eliminated, before the final report is written and accreditation action determined by the EAC the following July.

DEPARTMENTAL OPERATIONS

There are few aspects of departmental operations that are not impacted by Engineering Criteria 2000! I am an advocate for them, and am a strong believer in their value, having personally used them to guide the development of successful computer and electrical engineering programs during a seven-year term as department head at Rose-Hulman Institute of Technology [3], [4]. I have described the graduates of these new programs as ***Renaissance Engineers*** since they must possess new skills if they are to be successful in a rapidly changing professional workplace.

The focus of these new programs is to insure not only that graduates possessed the appropriate engineering skills, but also that they had ***learned how to learn***. Although it is difficult to admit, this is probably the most useful attribute we can instill in graduate engineers. Traditionally, most of us have regarded problem solving as the quintessential skill of an engineer, so, perhaps indeed, EC2000 has promoted a paradigm shift in engineering education.

The ABET EC2000 criteria were developed in response to requests from the academic community for a set of regulations that would allow engineering educators to develop more innovative programs. The new criteria relate to much more than the academic program and, in fact cover most aspects of the educational unit's operations. They could be described as an academic version of ISO 9000 – a process that has been described as one in which organizations have to ***"Say what they do – and do what they say".*** Both are built upon the foundations of total quality management (TQM) and continuous quality improvement (CQI).

The EC2000 requirements define a minimum standard and offer a great deal of flexibility to the faculty. After the initial steep learning curve associated with implementing EC2000, the work required at the maintenance level, is much less. There is no doubt that the discussions and actions that must take place "up front" are considerable - but necessary and extremely valuable. For the engineering education community, the result of this effort will be new and improved engineering programs. EC2000 will significantly benefit engineering employers who now should be able to hire graduate engineers who possess more appropriate skills. Furthermore, these new engineers should be prepared for productive careers upon graduation, and for career-long learning well into the twenty first century.

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