AC 2007-596: UNDERSTANDING ABET OBJECTIVES AND OUTCOMES

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ABSTRACT

Despite the maturing of the implementation of the EAC Engineering Criteria (EC2000), there persists a misinterpretation and misunderstanding regarding the program educational objectives and program outcomes. Many an engineering program still heads into the accreditation process without a clear sense of the meaning and implementation of these items.

This paper traces the development of the current definitions associated with ABET criteria 2 and 3 and provides insights into the resulting impact on program and curriculum development, specifically, the assessment process.

A useful understanding of objectives and outcomes can be achieved with a top-down approach. The process starts with the expected niche of the engineering world in which the graduates of an engineering program expect to pursue their intended/possible careers. The descriptors of the range of career paths and accomplishments expected of the graduates form the **program objectives**. The academic input and contribution that would foster and enhance the abilities of the graduates to achieve the intended career paths and accomplishments are limited to the years the graduate is a student. Hence, the skills and characteristics of the student at the time of graduation form the **program outcomes** since they are what a university is able to influence and attempt to assure. After establishing of the objectives and outcomes, consideration is given to the entire range of academic pursuits, from curriculum development to advising to institutional support activities. All of these form the vehicle for imparting the required knowledge and for channeling the development of the needed personal characteristics.

Index Terms – ABET Criteria, program objectives, program outcomes, assessment

INTRODUCTION

"Engineering Criteria 2000" (EC2000, now called the Engineering Criteria) was implemented in the later 1990s. Many aspects of the new criteria required a new mind-set and were quite different from the Traditional Criteria, which had significant elements of "bean counting." EC2000 at its heart was to allow greater freedom in how an engineering program defined itself via its intent, its constituencies' needs, and its curriculum [1][2][3]. But, along with freedom to choose comes the need to properly understand the new criteria and its implications.

One item of lingering confusion relates to the program educational objectives and program outcomes. Even now significant difficulties appear to exist in understanding the meaning of those terms and their relationship to each other [4]. At recent events, such as the fall 2005 ABET Summit [5], questions were again asked regarding what was the difference between objectives

and outcomes. Such confusion and the resulting need for clarification can be seen in the progressive change of wording over the years of Criterion 2 (Program Educational Objectives), Criterion 3 (Outcomes and Assessment) and in the Accreditation Policy and Procedure Manual.

Specifically (emphasis added by the authors):

- 2003-2004 Accreditation Cycle and immediate prior years – the criteria [6] only state:

  Criterion 2:
  "Each engineering program for which an institution seeks accreditation or reaccreditation must have in place: . . ."

  Criterion 3:
  "Engineering programs must demonstrate that their graduates have: . . ."

  Further, the Accreditation Policy and Procedure Manual, AY03-04 [7], makes no mention of any definitions.

- 2004-2005 Accreditation Cycle – the criteria [8] were changed to state:

  Criterion 2:
  "Although institutions may use different terminology, …. **program educational objectives are intended to be statements that describe the expected accomplishments of graduates during the first several years following graduation from the program**.

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

  Criterion 3:
  "Although institutions may use different terminology, …. **program outcomes are intended to be statements that describe what students are expected to know or be able to do by the time of graduation from the program**.

  Engineering programs must demonstrate that their graduates have: . . ."

  The Accreditation Policy and Procedure Manual, AY04-05 [9], again makes no mention of any definitions.

- 2005-2006 and the 2006-2007 Accreditation Cycle – the criteria [10, 11] showed further revisions:

  Criterion 2:
  "Although institutions may use different terminology, …. **program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve**.

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

Criterion 3:

"Although institutions may use different terminology, …. **program outcomes are statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that student acquire in their matriculation through the program**.

Each program must formulate program outcomes that foster attainment of the program objectives articulated in satisfaction of Criterion 2 of these criteria. ……

Engineering programs must demonstrate **that their students attain**:"

The Accreditation Policy and Procedure Manual, AY05-06 and AY06-07 [12, 13], now also adds further clarification:

"II.D. **Interpretation of Criteria**

II.D.1. Definitions – While ABET recognizes and supports the prerogative of institutions to use and adopt the terminology of their choice, **it is necessary for ABET volunteers and staff to have a consistent understanding of terminology. With that purpose in mind, the Commissions will use the following basic definitions**:

II.D.1.a. Program Educational Objectives – **Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve**.

II.D.1.b. Program Outcomes – **Program outcomes are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program**."

At our institution the early perception of program educational objectives centered on the objectives as "lofty goals," something to strive towards, and there were minimal expectations of the assessment of the objectives. There was no specific context of associating them with career achievements in the early years post-graduation. Little documentation appears to be available to determine how widespread that understanding was [14]. The specific wording, as published in the annual updates of ABET, most certainly have evolved to provide greater clarity. What is also needed is clarity of how the current understanding relates to and affects program development and assessment. This paper provides such details.

TOP-DOWN PROGRAM DEVELOPMENT MODEL

If one were to design a new engineering program, from scratch, how would one do it? How does one think about the process of developing program objectives and program outcomes? Is this a chicken and egg type of question? No, the program outcomes derive from the program objectives. The current definition of objectives and outcomes provides a clear road map for a process that addresses those questions. There is a hierarchy to the process and it is a top-down

process that begins with the Program Educational Objectives. This is made clear by the wording from Criterion 3 "**Each program must formulate program outcomes that foster attainment of the program objectives articulated in satisfaction of Criterion 2 of these criteria."** If the outcomes are to support the objectives, the objectives must be defined first. Hence, the sequential process of program development is:

- The professional/occupational niche must be identified that the graduates of the program are to "occupy." The institution identifies a specific range of careers for which its graduates will be primarily prepared.
- The **program educational objectives** are defined as broad statements that describe the career and professional accomplishments, during the first several years following graduation, that are consistent with reasonable and successful entry into the identified professional/occupational niche.
- The **program outcomes** are defined in terms of the collective professional judgment of what students are expected to know and be able to do by the time of graduation such that they will successfully fulfill the program objectives. Therefore, this body of knowledge and understanding must foster and enhance the ability of the graduates to achieve the intended career paths and professional accomplishments. By necessity, this component is limited to what occurs during the time that the student is in the care of and under the influence of the program.
- Only now may the **curriculum** and all other aspects of the program be developed to ensure that the desired body of knowledge and understanding is imparted to the graduates. The organization of the curriculum usually is in the form of prescribed course requirements but could, potentially, be achieved in any one of a number of innovative ways [15]. It should be noted that Criterion 4:
  - Specifically only mentions "The faculty must ensure that the program curriculum devotes adequate attention and time to each component."
  - And, "The professional component must include: (a) one year of a combination of college level mathematics and basic sciences."
  - No requirement is placed on the program as to how the material will be delivered to the students. While the tendency is to read the word "courses" into the criterion, only the minimum time devoted to various broad topics is referenced.
- All of these steps must involve at least some of the eventual constituencies of the defined program (faculty, prospective employers, etc.).
- With program procedures and policies and an appropriate curriculum in place the assessment process begins and eventually matriculated students graduate and start to pursue their intended career paths.
- And then the program assessment process is used to focus the curriculum and student outcomes to achieve the program objectives, to provide "course" corrections, and to implement a process of continuous improvement.

Key to the understanding of the outlined sequence, from objectives to courses, is the manner of forming a structure in which one component supports another component. Hence, in its most simple format the structure consists of:

1. Objectives are expected career descriptors

2. Outcomes are graduates' attributes that foster the achievement of the objectives
3. The curriculum/courses/other program aspects are to instill the outcomes

The structure may be compared to a fruit tree. The curriculum, courses, and other program aspects are the trunk that supports the outcomes and objectives. The branches form the structure of the program outcomes. Finally, the objectives are the fruit yielded by educated and informed graduates.

EXISTING PROGRAMS AND THE IMPACT OF ASSESSMENT

EC2000 happened long after virtually all existing engineering programs were already well established. Hence, for most programs the idea of doing a sequential top-down process in real time is not realistic. However, the key to understanding the contribution of the top-down process is that the entire structure of program objectives, program outcomes, curriculum content, etc., must align with the top-down model. Hence, the model's relevance to existing programs is not diminished.

The assessment process is the driver that aligns the components of the top-down model. Assessment generally takes place simultaneously at many levels in a program and it takes place along different time scales. Anything from surveys to alumni focus groups measure the extent to which the graduates in their early years follow the expected career paths and achieve the projected achievements defined by the program objectives. Outcomes assessment in the form of standardized exams (FE exam, etc.) or course assessment (comprehensive final exams, prerequisite exams, laboratory exams, written reports, oral presentations, etc.) provide possible means of demonstrating that the chosen performance thresholds defined by the program outcomes are met. Further, assessment tools can involve the advising process, senior exit interviews, etc. If the assessment data provided by these tools confirm the existence of problems whereby some objectives or outcomes are not met, then how does the top-down process direct the responsive actions to be taken? Some examples will illustrate the process.

Example 1: What if the assessment process finds the program educational objectives are not being met in some substantial manner? There are various possibilities to consider, such as:

1. Focus on the outcomes: determine if the program outcomes are truly being met. Are the performance thresholds for the outcomes too low and, hence, the preparation is inadequate?
2. Focus on correlation with program outcomes: Does the program have the right outcomes that would allow the objectives to be met? Potentially, the outcomes are being met but consist of providing the wrong preparation for the career expectations.
3. Focus on the objectives: Is it possible that the career expectations are no longer sufficiently relevant in a rapidly changing technological/global environment?

Example 2: What if the assessment process finds the program outcomes are not being met in some substantial manner? Some possibilities are:

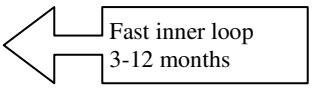
1. Focus on topic coverage: Are the thresholds for meeting the outcomes consistent with the depth and breadth of topic coverage?

2. Focus on correlation with course outcomes: Do the course outcomes map adequately into providing the desired program outcomes or are there gaps in coverage?
3. Focus on the program outcomes: Does a review of the curriculum truly suggest the specified outcomes are the proper resulting outcomes or is the curriculum really heading the student in a different direction? Is retention of information a learning problem? Is the curriculum organized to reinforce learning?
4. Focus on the program: Are there program aspects, such as professional guidance, that are insufficient or done poorly? Are learning opportunities limited to single events and not retained?

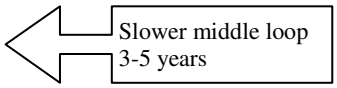
In the examples, the assessment process should reveal whether the program objectives or outcomes are being met and provide an indication of why. But whatever the causes, all corrective action must include aligning all components and strengthening their support as described in the top-down model. Only then can the final result be satisfactory across all aspects of the program. The options for implementing corrective action include changing objectives, changing outcomes, changing the curriculum, and changing other critical aspects of the program. It is also essential to remember that all these changes must be done with input from the constituencies of the program. But all such changes are possible to make and are allowed under the new Engineering Criteria.

A cursory flowchart manner of presenting the information in the examples is as follows:

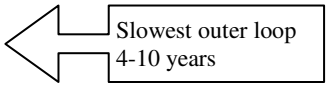
- Does the curriculum result in the desired course outcomes?
  - If yes – keep monitoring
  - If no – corrective action
    - Course outcomes are poor



- Do the students at graduation exhibit the desired outcomes?
  - If yes – keep monitoring
  - If no – corrective actions, including addressing causes
    - Program outcomes are poor
    - Program outcomes as desired but are not supported by course outcomes



- Do the graduates have the expected career paths?
  - If yes – keep monitoring
  - If no – corrective actions, including addressing causes
    - Program objectives are poor
    - Program objectives are proper but are not supported by program outcomes



- Difficulties can be found at any level (curriculum, program outcomes, and program objectives). Assessments are all done in parallel.
  - Curriculum assessment is the "canary in the mine"
  - Each level has its own "time constant"
- Example assessment result: Poor program outcomes
  - Expect with time to affect program objectives
  - Fixing the program outcomes is determined to cost money
  - Could change program outcomes which may require changing objectives
- Must provide continuous assurance of bottom to top alignment and support (think of a scaffold)

Even with the examples given, there are two points we believe require serious consideration: The implementation of a given assessment tool does not necessarily assure data that delineates as clearly as one would like between measuring program objectives versus measuring program outcomes and that forethought before implementation is a central aspect of effective assessment. Data resulting from a given assessment tool could provide relevant insight into both objectives and outcomes.

For example, consider alumni surveys as a potential instance. What if the question is asked "Did you achieve your career goals?" A number of possible issues need to be considered in analyzing the data:

- Are the career goals the alumni have in mind consistent with the objectives of the program? Are other questions asked that provide clarification? What if there is affirmation of satisfaction of career paths? The alumni could be achieving results to their pleasing but still be inconsistent with the objectives of the program.
- The overall data may provide direct insights on aspects of the curriculum, and resulting outcomes, or simply that graduates are not following expected career paths.
- And, note the switch in language, often casually done, of using "goals" versus "objectives." Is this important? Careless use of terminology in the case of "objectives" and "outcomes" can lead to serious misunderstandings.

The main lesson is that data analysis should start before an assessment tool is implemented. Consideration should be given up front, not just to the possible range of data that might result, but also to whether the resulting data is useful and addresses the desired issues.

Feedback from employers can also provide information on both objectives and outcomes. If employers state that graduates need better communication skills, that suggests both an impact on program outcomes (communication skills being part of (a)-(k)) and potentially limiting alumni in their career path of professional advancement, highly likely to be part of the program objectives. "Senior Exit Survey" information is another example. Since the outcomes are to support the ability to pursue specified career paths, problems uncovered at the senior level presumably would impact the objectives. If such is not the case, what purpose does a given outcome serve?

One approach to program development, which runs totally counter to the top down process model implicit in EC2000, is to simply take a collection of courses and pronounce the result as a new program of study. Thus, a bottom-up process would have been followed. The outcomes would be determined by the course content. Such a process is akin to finding pieces of LEGO and proceeding to put the pieces together to build something, a pursuit of building without design. There would be no clear idea of what the result should/will look like, only the idea of "have pieces, let's build." Compare this to the process requirements and professional constraints we require of students in their capstone experience. We would never allow students to pursue such a "worst case" design scenario.

"MORE ASSESSMENT BANG FOR THE BUCK"

Surveys are notoriously difficult to implement and the resulting data are often challenging to interpret. A common reason is the lack of effort to think through the survey questions to assure no ambiguity. This is essential to achieve clarity in the resulting data. All too often there is the

approach of tossing a group of questions together and "we will sort things out later when we have gotten back data." Similarly, objectives and outcomes should serve as a compass setting whereby the assessment process can provide a clear sense of direction the program is intending to follow and allow for continuous corrections (improvements).

And, there is an additional impact. Clarity and consistency of objectives and outcomes allows a program to articulate its values and educational process. If the assessment process drives the alignment of objectives, outcomes, curriculum, and other vital program factors, the program's message will be more readily understood by students, alumni and employers. Strong program support should result because the program's message is understood to be important, is believed and is being delivered.

CONCLUSION

The proper relationship between the ABET Engineering Criteria Program Educational Objectives and Program Outcomes is readily demonstrated using a top-down program process model. The relationship is driven by the current definitions as provided in both the Engineering Criteria and the Accreditation Policy and Procedure Manual. While the top-down model was initially introduced for an ideal situation involving the development of a program from start, it is equally relevant for existing programs and provides the needed guidance in assessment and program development to assure alignment of the objectives and outcomes to assure the intended success of a program's graduates.

BIBLIOGRAPHY

[1] Lisa R. Lattuca, Patrick T. Terenzini, J. Fredericks Volkwein, Linda C. Strauss, ABET EC2000 Study, "Engineering Change: A Study of the Impact of EC2000", Report – Oct., 2005.
[2] Volkwein, J. F., Lattuca, L. R., Terenzini, P. T., Strauss, L. C., Sukhbaatar, J., "Engineering Change: A Study of the Impact of EC2000". *International Journal of Engineering Education*, 20(3), (2004), 318-328.
[3] Prados, J. W., Peterson, G. D., and Lattuca, L. R., "Quality Assurance of Engineering Education through Accreditation: The Impact of Engineering Criteria 2000 and Its Global Influence". *Journal of Engineering Education*, 94(1), (2005), 165-184.
[4] Mayes, T.S.., Bennett, J.K., "ABET Best Practices: Results from Interviews with 27 Peer Institutions," *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition.*
[5] 2005 ABET Commission Summit, October 26, 2005, San Diego, CA
[6] CRITERIA FOR ACCREDITING ENGINEERING PROGRAMS, (2003-2004 Accreditation Cycle), Engineering Accreditation Commission, 11/15/02
[7] ACCREDITATION POLICY AND PROCEDURE MANUAL (2003-2004 Accreditation Cycle), Engineering Accreditation Commission, 11/13/02
[8] CRITERIA FOR ACCREDITING ENGINEERING PROGRAMS, (2004-2005 Accreditation Cycle), Engineering Accreditation Commission, 11/19/03
[9] ACCREDITATION POLICY AND PROCEDURE MANUAL (2004-2005 Accreditation Cycle), Engineering Accreditation Commission, 11/19/03
[10] CRITERIA FOR ACCREDITING ENGINEERING PROGRAMS, (2005-2006 Accreditation Cycle), Engineering Accreditation Commission, 11/17/04
[11] CRITERIA FOR ACCREDITING ENGINEERING PROGRAMS, (2006-2007 Accreditation Cycle), Engineering Accreditation Commission, 10/29/05
[12] ACCREDITATION POLICY AND PROCEDURE MANUAL (2005-2006 Accreditation Cycle), Engineering Accreditation Commission, 11/29/04

[13] ACCREDITATION POLICY AND PROCEDURE MANUAL (2006-2007 Accreditation Cycle), Engineering Accreditation Commission, 11/17/05
[14] Leonard, M.S., Nault, E.W., "An Integrated Approach to Evaluation of Program Educational Objectives and Assessment of Program Outcomes Using ABET Criteria for Accreditation of Engineering Programs," *Proceedings of the 2004 American Society of Engineering Education Annual Conference & Expostion*.
[15] Karl. D. Stephan, "All This and Engineering Too: A History of Accreditation Requirements," *IEEE Technology and Society Magazine*, vol. 21, issue 3, pp. 8-16, Fall 2002.