Documenting Continuous Improvement for ABET Accreditation Review

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Abstract - The newly revised ABET Criteria for the Accreditation of Engineering Programs require engineering programs to have processes that support and confirm continuous programmatic improvement. This paper provides a description of an approach to integrate program educational objective and student outcome achievement measurements, along with other program performance-related data that may be available to an engineering program. The approach suggests a mixed-model design for quantitative and qualitative evaluation that provides a summary of the benefits of program status improvements in terms of comparison to a program specific baseline. Continuous improvement is demonstrated by an aggregation of accumulated changes to program educational objective and student outcome achievement measures, along with a collection of qualitative characterizations of change. This approach is illustrated by the use of an example.

Keywords: ABET Accreditation, Continuous Improvement

MOTIVATION

The ABET 2011-2012 General Criteria for Engineering Programs have substantially revised "Criterion 4. Continuous Improvement." Criterion 4 now specifies [ABET, 1]

> "The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which both the program educational objectives and the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program."

Under the revised criterion, the faculty of engineering programs must present a case for continuous programmatic improvement primarily on the basis of changes in program educational objectives and student outcomes achievement measures supplemented, as appropriate, by evaluation of program changes made outside the mandated assessment and evaluation loops.

SOURCE DATA: PROGRAM EDUCATIONAL OBJECTIVES, STUDENT OUTCOMES, AND OTHER AVAILABLE INFORMATION

The Engineering Accreditation Commission (EAC) of ABET Criteria for Accrediting Engineering Programs state that accredited programs "must regularly use appropriate, documented processes for evaluating the extent to which both the program educational objectives and the student outcomes are being attained." Hence, findings from periodic program educational objectives (PEO) achievement confirmations will be available to the program faculty for evaluation from any given time reference baseline [like the time of program initiation or the time of the last accreditation visit] to the present. Similarly, findings will also be available from periodic student outcomes (SO) achievement confirmations from any given time reference baseline to current status.

The EAC criteria specify that evaluation "results in decisions and actions regarding program improvement." Thus, to document the mandated evaluations of PEOs and SOs requires that the program have available descriptions of

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program changes made to close loops of PEO/SO assessment and evaluation from any time reference baseline to the present.

Similarly, any carefully managed academic program should also have available descriptions of program changes made outside PEO/SO assessment and evaluation loops, including documentation of the circumstances which motivated program changes and information which describes the consequences of each change. This information should also be available from any given time reference baseline to the present.

EVALUATION OF DATA TO MAKE THE CASE FOR CONTINUOUS IMPROVEMENT

A program under accreditation review must make the case in its Self Study and to its accreditation visitors that continuous improvement of the program has occurred. Unfortunately, the research community provides no one best way to make such an argument. In fact, [Cronbach, 3] argues that "There is no single best plan for an evaluation, not even for an inquiry into a particular program at a particular time..." [Greene, 4] notes that the validity of research findings can be strengthened by triangulation - using more than one method to study the same phenomenon. One way to accomplish triangulation with respect to continuous improvement documentation is to select one or more approaches to gather quantitative and qualitative data which characterizes program status changes.

Arguably, the most effective approach to integrating qualitative and quantitative methods would be to use a qualitative method to identify possible areas of improvement, then a quantitative method to quantify magnitudes of identified improvements, followed by a qualitative method to clarify quantitative findings as needed [Miles, 5]. However, EAC Criterion 4 mandates that PEO and SO achievement assessments and evaluations be utilized as inputs for the continuous improvement of the program. It is reasonable to assume that most engineering programs will take what could be perceived as the most expeditious path to confirming each PEO and SO achievement – comparing a quantitative aggregate measure of (PEO or SO) performance to an associated quantitative performance target. This is particularly likely since academic programs do not have unlimited resources to pursue multiple cycles of qualitative and quantitative evaluation.

Thus, this paper will present a mixed method design for establishing continuous programmatic change that begins with the use of quantitative methods. The design then uses qualitative methods to strengthen the argument for improvement by providing additional details concerning the benefits of program changes.

A program can demonstrate continuous improvement over time quantitatively by highlighting "accumulated changes" between baseline and current PEO and SO measures. One of many possible ways to provide quantitative displays of accumulated changes is the spider chart (also called a radar chart). The spider chart is a graphical method of displaying multivariate data in the form of a two-dimensional illustration with three or more quantitative variables represented on axes starting from the same point [Chambers, 2].

In addition, a program can demonstrate continuous improvement over time *qualitatively* by itemizing programmatic changes made *inside* the PEO/SO assessment and evaluation (A & E) loops and securing constituent (particularly student, alumni, employer, and advisory board) evaluations of the benefit(s) of each of these changes.

Similarly, a program can demonstrate continuous improvement over time *quantitatively and qualitatively* by itemizing programmatic changes made *outside* the PEO/SO A & E loops and securing institutional data and constituent (particularly student, alumni, employer, and advisory board) evaluations of the benefit(s) of each of these changes.

For the sake of completeness, the Self Study for a program under review should also indicate any plan(s) the program faculty has for future program improvement based upon recent evaluations. A brief rationale should be provided for each planned change.

EXAMPLE

The material that follows provides an opportunity to demonstrate the concepts discussed in this paper. Consider the display for the XYZ engineering program at ABC University of six academic years of PEO and SO achievement data in terms of overall objective or outcome measure score [aggregate performance for the objective or outcome]/score set by the faculty to indicate achievement of the objective or outcome [threshold score] display

shown below. Here, for example, in academic year 04/05 PEO "1. successful practitioner" had an overall performance measure score of 73 in comparison to the faculty set threshold score of 75.

Academic Year	04/05	05/06	06/07	07/08	08/09	09/10	
Program Educational Objectives (PEO)							
1. successful practitioner	73/75		72/75		77/75		
2. excellent communicator	88/75		86/80		91/80		
3. completed graduate education		48/50		49/50		51/50	
4. community leader		64/60		65/65		66/65	
Student Outcomes (SO)							
1. mathematics, science and engineering knowledge	77/80		77/80		79/80		
2. design/conduct experiments		84/80		82/80		83/80	
3. design system/component	86/80		87/80		88/80		
4. function on teams		90/85		88/85		91/85	
5. solve engineering problems		84/80		83/80		83/80	
6. ethical responsibility		92/85		90/85		92/85	
7. communicate effectively		93/85		91/85		93/85	
8. engineering solutions impact			92/85		92/85		94/85
9. life-long learning		86/85		84/85		87/85	
10. contemporary issues		86/80		88/80		88/85	
11. engineering tools for practice			87/80		88/80		89/85

Programmatic Changes made in response to PEO/SO assessment and evaluation

1. Program faculty added a senior seminar series emphasizing graduate study and research in Spring 2008 when Program Educational Objective 3 failed to meet specified performance achievement threshold in 2004/2005 and 2006/2007.
2. Program faculty took steps to strengthen the core engineering mechanics sequence in Fall 2007 when Student Outcome 1 results failed to meet specified performance achievement threshold in 2004/2005 and 2006/2007.

Programmatic Changes made outside the PEO/SO assessment and evaluation cycle

A School of Engineering-wide retention effort with mandatory supplemental instruction in each freshman- and sophomore-level mathematics, science, and engineering science course was instituted in Fall 2008.

No significant future program improvements are currently being planned.

1. How would you make the case to demonstrate quantitatively that continuous improvement had occurred in the XYZ engineering course at ABC University?
2. What information would you try to gather for your accreditation visitor to make the case qualitatively for continuous quality improvement?

To make a case that the XYZ engineering program has experienced continuous improvement, a hypothetical mixed method design providing quantitative and qualitative evidence will be presented.

A logical first step in developing this display of evidence is to make a choice of how to consolidate the quantitative data that are available to the program. Since academic year 04/05 is the first year of data available and it appears that the program is using a two-year cycle for collection of PEO and SO achievement data, the aggregation of 04/05 and 05/06 data can be used as the base year for confirmation of continuous improvement. Similarly, 08/09 and 09/10 are the last sets of data available, thus the aggregation of 08/09 and 09/10 data can be used to represent the program's current status.

Objectives and outcomes achievement data, as well as threshold achievement scores, have been provided. A simple way to view performance data in relation to threshold scores is to calculate a ratio for each PEO and SO. Thus, for example, the ratio associated with the educational objective "1. successful practitioner" in academic year 04/05 is 73/75 = 0.97. With this ratio form of representation, the end points of six years of performance data for the XYZ can be displayed in the spider chart shown in Figure 1.

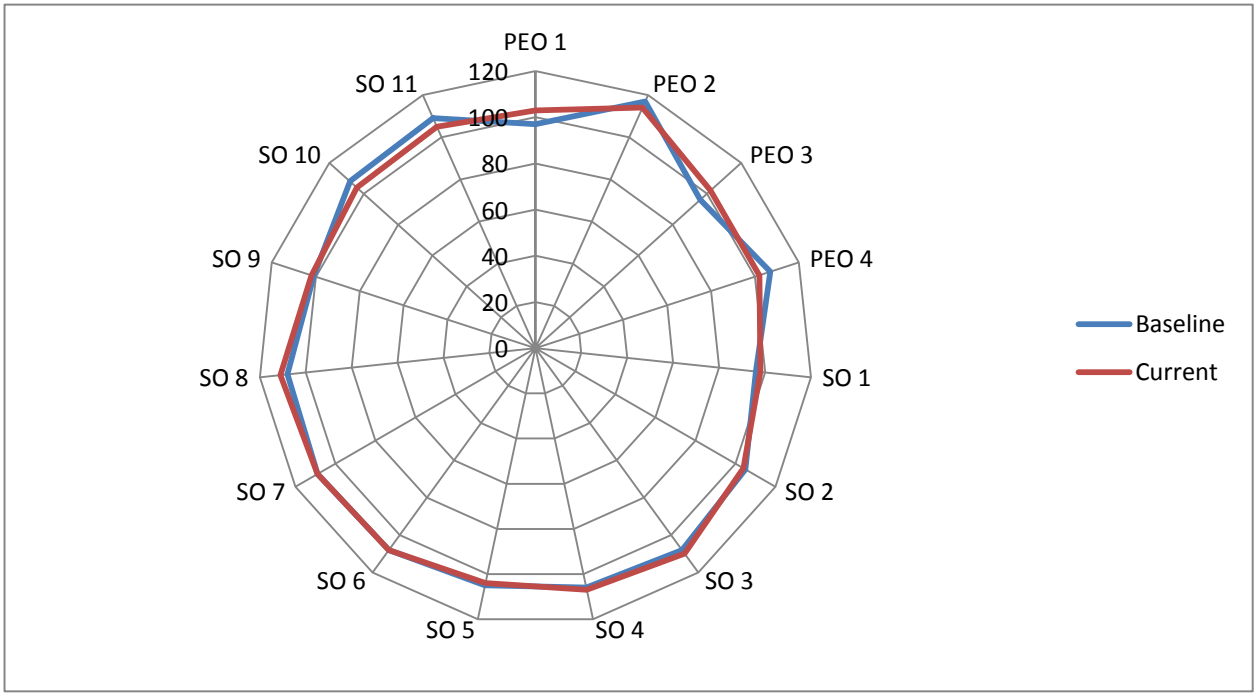

Figure 1: Quantitative Evaluation: Six Years (04/05 to 09/10) of PEO/SO Achievement Data – as fractions of thresholds

This spider chart showing changes in PEO and SO achievement data should be accompanied by a listing of the program changes made to close loops of PEO/SO assessment and evaluation from the time reference baseline to the present. From a quick scan of the spider chart, it is clear that program changes made by the faculty in response to Criteria 2, 3, and 4 mandated PEO and SO monitoring, assessment, and evaluation have not been seriously detrimental to program performance. A closer examination of the spider chart and associated data provide positive but not overwhelming evidence that the program has improved across the reporting period.

In addition to the programmatic changes made in closing loops of PEO/SO assessment and evaluation, the information provided in the example states that there was a School of Engineering-wide retention effort with mandatory supplemental instruction instituted in each freshman- and sophomore-level mathematics, science, and engineering science course in Fall 2008.

For the purpose of illustration, the XYZ engineering program could document the benefits of this change quantitatively by displaying ABC University retention fraction data for *program* freshmen and sophomores, as shown in Table 1 below.

Table 1: Retention Fractions
XYZ Program

	2007-2008	2008-2009	2009-2010
Freshmen	0.84	0.88	0.91
Sophomores	0.86	0.87	0.92

These hypothetical data complement the positive findings from the examination of PEO and SO achievement results. Still, it would be good to be able to provide constituent-based confirmations that program improvement has occurred. It is proposed that these confirmations be done with qualitative methods using information provided by program constituents.

Qualitative evaluation – six years (04/05 to 09/10) of changes within the A & E loop

- Program faculty added a senior seminar series emphasizing graduate study and research in Spring 2008 when Program Educational Objective 3 failed to meet specified performance achievement threshold in 2004/2005 and 2006/2007.

The benefits of this change could, as an example, be evaluated qualitatively by: (1) interviewing a sample of graduating senior XYZ engineering program students to determine areas of interest gained as a result of participating in the senior seminar, and (2) developing a list of current issues of importance in graduate study and research in the XYZ discipline as determined by a focus group of faculty colleagues meeting at a national professional society conference.

Consider the following illustration of results that might have been gained from the hypothetical qualitative evaluation described in the paragraph above. Evaluation of the student interviews revealed that 80% of the interviewed students shared three areas of interest gained from participating in the newly-adopted senior seminar series: "anticipating environmental impacts of new product development," "computational limitations of currently-available analysis tools," "and exploring issues of process stability and control in very high-temperature operating conditions." Similarly, in a consensus-generated list of current issues of importance in graduate study and research, the focus group of faculty colleagues placed "environmental impacts of new product development" and "process stability and control under very high-temperature operating conditions" among the top five areas. In addition, nine of the fifteen topics covered in the senior seminar over the last two years were on the focus group's ranked list of current issues of importance.

Although these results of benefits associated with the addition of a senior seminar series come from hypothetical qualitative evaluations of two sets of sample findings, had they been actual results, they would have provided relatively strong evidence of XYZ program improvement coming from the addition of a senior seminar series. This same process of triangulation can be used to strengthen the argument of program improvement associated with other changes made within, and outside, the A & E loop.

- Program faculty took steps to strengthen the core engineering mechanics sequence in Fall 2007 when Student Outcome 1 results failed to meet specified performance achievement threshold in 2004/2005 and 2006/2007.

As was the case with the addition of the senior seminar series, the benefits of strengthening the core engineering mechanics sequence could be evaluated qualitatively by: (1) conducting interviews with a sample of program students to determine and then report on changes in student perceptions concerning their knowledge of core

mechanics concepts and ability to solve core mechanics problems, and (2) conducting interviews with a sample of instructors of courses following the core mechanics sequence to determine and then report on changes in instructor perceptions concerning student knowledge of core mechanics concepts and ability to solve core mechanics problems.

Qualitative evaluation – six years (04/05 to 09/10) of changes outside A & E loop

- A School of Engineering-wide retention effort with mandatory supplemental instruction in each freshman- and sophomore-level mathematics, science, and engineering science course was instituted in Fall 2008.

Again, the benefits of this change could be documented qualitatively by: (1) conducting interviews with a sample of program students to determine and then report on changes in student perceptions concerning preparation for upper-level engineering coursework, and (2) conducting interviews with a sample of program faculty to determine and then report on changes in faculty perceptions concerning student engagement in curriculum coursework.

Suppose the actual findings from the qualitative evaluations of the strengthening of the core mechanics sequence and the addition of supplemental instruction were similar in levels of support to the example findings described for the senior seminar series. Then, if these three sets of qualitative findings were displayed along with the quantitative evidence of program improvement presented earlier in this paper, the XYZ engineering program would have especially strong evidence of continuous improvement across the accreditation review period.

SUMMARY

Providing compelling evidence concerning the success of a program's continuous improvement activities is a key component in ABET accreditation of an engineering program. This paper has presented a mixed method approach to developing and displaying evidence needed to make that case.

REFERENCES

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