AC 2010-392: SUSTAINABLE ASSESSMENT FOR PROGRAM IMPROVEMENT AND ABET PREPARATION

Richard Kelnhofer, Milwaukee School of Engineering

Dr. Kelnhofer is Program Director of Electrical Engineering Technology and Assistant Professor at Milwaukee School of Engineering (MSOE). Formerly, he held engineering and managerial positions in the telecommunications industry. He received his Ph.D. in Electrical Engineering from Marquette University in 1997 and is a Professional Engineer registered in the State of Wisconsin. Dr. Kelnhofer teaches courses in communication systems, signal processing, and information and coding theory.

Stephen Williams, Milwaukee School of Engineering

Dr. Stephen Williams is Program Director of Electrical Engineering and Professor of Electrical Engineering and Computer Science at Milwaukee School of Engineering (MSOE). He received the Ph.D. degree from the University of Missouri in 1990 and has 20 years of experience across the corporate, government, and university sectors. He is a registered Professional Engineer in Wisconsin. He teaches courses in control systems, electronic design, and electromechanics.

Owe Petersen, Milwaukee School of Engineering

Dr. Petersen is Department Chair and Professor of Electrical Engineering and Computer Science at Milwaukee School of Engineering (MSOE). He is a former Member of Technical Staff at AT&T Bell Laboratories and received his Ph.D. degree from the University of Pennsylvania in 1971. His technical work ranges over the topics of optical data links, integrated circuit technology, RF semiconductor components, and semiconductor component reliable. He is a Senior Member of the IEEE and an ABET EAC program evaluator in Electrical Engineering.

Sustainable Assessment for Program Improvement and ABET Preparation

Abstract

One of the fundamental challenges of program assessment is to develop a process that is sustainable and has the rigor to deliver the results required for continuous improvement. At the same time the process should on a steady basis be able to provide the data that is expected to be an integral component in the preparation of the ABET Self-Study when the time comes for requesting accreditation.

In this paper we describe such a process. The process consists of three components:

1. A fast feedback procedure to implement continuous improvement at the course level. This procedure includes a course improvement form completed by the course instructor that documents their positive and negative reflections, suggested actions for course improvement, and deviations from the institutional syllabus in their offering of the course. A mechanism for evaluating and implementing suggested improvements is detailed.
2. A program outcome assessment procedure that directly assesses specific program outcomes and implements curricular changes resulting from evaluation of the data. This procedure incorporates an outcome assessment form with assessment tools, rubrics, benchmarks, and suggested curricular actions. The application of the form to the outcome assessment procedure for creating, implementing, and evaluating curricular change is explained.
3. Ongoing documentation of the process is accomplished via an institutionally-mandated annual program audit. The audit is based on essential elements that are consistent with, and mirror the format of the ABET Self-Study. Details and reflections on this audit by two program directors are included.

Program outcomes are assessed *directly* and not inferred from course outcomes. Specific assignments are required in courses designated to provide the evidence in the form of student work that demonstrates the extent to which the program outcomes are met. The result of this process is to consistently gather data that is critical for the ABET Self-Study and provide ongoing curriculum continuous improvement at both the course and program levels. Key observations are that decision-making has become more formalized and subject to more rigorous, documented scrutiny. Faculty buy-in to the process has been very favorable because of the ease and clarity of the tasks to be done.

Introduction and Purpose

Undergraduate engineering programs are discovering the benefits and costs of continuous improvement.[1-10] Since the 2006-07 accreditation cycle ABET has required programs to implement a Continuous Improvement Process (CIP). The plan must demonstrate evidence of actions which improve the program based on the assessment and evaluation of a program's objectives and outcomes. In the 2009-10 accreditation cycle the ABET Criteria for Accrediting

Engineering Programs established Criterion 4 Continuous Improvement as a separate criterion.[11]

Long before ABET formally required continuous improvement, effective engineering faculty and programs utilized many ad hoc procedures to improve their performance. For example, instructors constantly assess student learning through comparison to standards that represent competency in course material. Self-reflection and peer interaction often occur during and after teaching a course. These ad hoc procedures and interactions create tribal knowledge that form an institutional history. Such a history can enrich and improve the program on a continuous basis. However, in such an environment program administrators are challenged to collate and leverage the collective knowledge of the program's faculty in their efforts to steer the overall curriculum towards greater effectiveness. Further, Whiteman contends that "If the learning community, to include students, faculty, and constituents, are able to continuously improve the teaching and learning experience for the students, the assessment process should be considered a success."[12]

While ad hoc methods are beneficial, a formal institutional-based continous improvement process is required to create a sustainable process while simultaneously minimizing costs of implementation. Numerous Continuous Improvement Processes (CIP) models exist and are well studied. Such models include plan-do-check-act, Six Sigma, and Total Quality Management (TQM).[13-14] One key factor that determines the success and sustainability of each of these CIP initiatives is the active participation in the CIP by all participants involved. A second key factor is the communication of the findings and the results to all the participants. A third factor is simplicity since it is unrealistic to expect a high level of training for all participants.

The ability to continuously improve is conditioned on the sustainability of the process.[15-17] The pre-ABET continuous improvement procedures used by faculty, albeit somewhat effective, had been ad hoc, disparate, and largely undocumented. There is an administrative overhead cost that is incurred to standardize and document continuous improvement processes. The benefits to be had include compliance with ABET requirements, systematic change, and documented improvement rising above the course level to the curricular level.

The process described in the remainder of this paper has been adopted by multiple engineering and technology programs at our university. It was designed with two overriding specifications: sufficiency and sustainability. The process contains many Kaizen principles[18] such as:

- Improvements are made using small changes that do not require large investments
- Ideas for improvements come from those closest to the process and most capable for the success
- The active parties take ownership of the improvement process

In addition, the overall process contains essential elements that are consistent with and mirror the format of the ABET Self-Study.

Overview of the Process

Central to the continuous improvement process are two program level assessment forms:

1. *Course Improvement* form
2. *Program Outcome Assessment* form

In addition, the assessment process requires the collection of evidence in the form of *assessed student work*. Together these will provide evidence in the ABET Self-Study and during the evaluation visit.

The purpose of the assessment forms is to have an easy to understand, transparent, and sustainable assessment process that is synergistic with the review of student work. They are used by all faculty of the department for course related assessment.

A graphical overview of the process is shown in Figure 1. The information resulting from this process potentially flows from the course instructor to the course coordinator and Program Director. Each Program Director presents an annual review of the results to the faculty of that program.

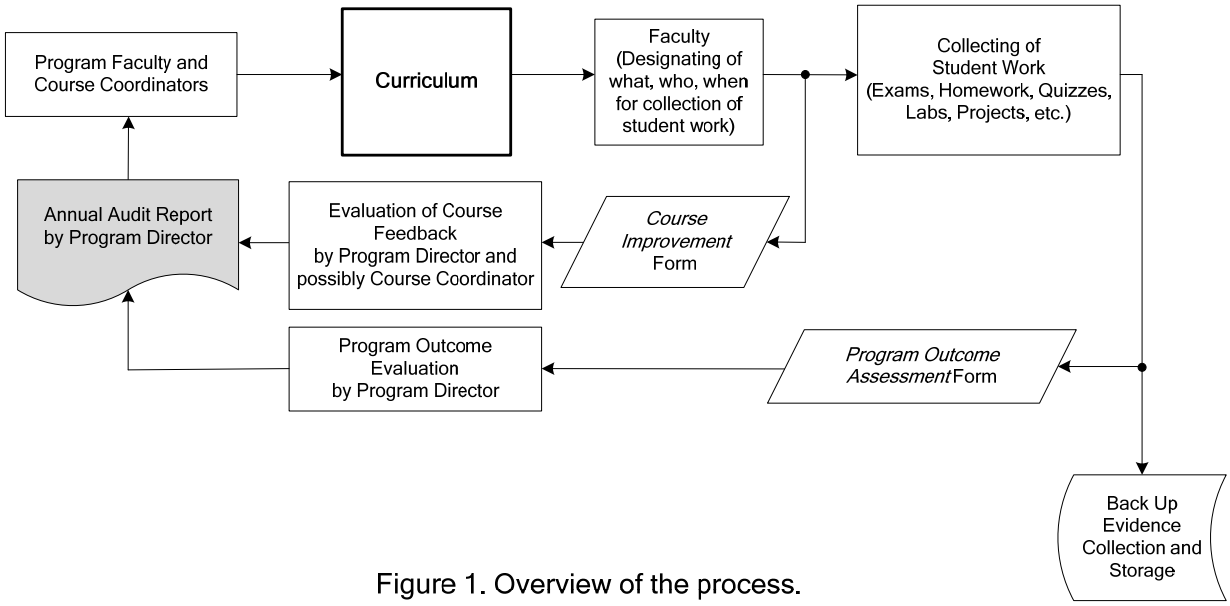

Figure 1. Overview of the process.

Course Level Continuous Improvement

The procedure developed for course level continuous improvement was designed to formalize and document what conscientous faculty were already doing. Guided by a directed set of questions, faculty reflect on their experience in a course just taught. A sample of the course improvement form used for this purpose is shown in Appendix 1. It is noted that most of the course improvement forms filled out by the faculty have few comments. The sample in Appendix 1 was intentionally chosen for this paper to illustrate the process.

After reviewing the catalog description, course prerequisites, and course outcomes for their course, the faculty responds to the following:

- Deviation from published catalog description and/or course outcomes
- Course modifications (e.g., topic sequence, catalog description, schedule, etc.) made since the last time the instructor taught the course
- Proposed actions for course improvement
- Positive and/or negative reflections on course (including relevant student feedback, if any)

The faculty completes and submits this form via e-mail during final exam week. The department administrative assistant files all completed forms on a server. All faculty have access to this server. It has become an excellent resource of institutional history for faculty who are preparing to teach a course, who are modifying a course, and who are creating new courses.

For completed forms that indicate program director or course coordinator notification is needed, the department administrative assistant forwards those forms to the appropriate person. It is the responsibility of the course coordinator and/or the program director to develop and execute an action plan that addresses the concerns expressed on the form. The action plans are presented, discussed, and, if necessary, approved at a program faculty meeting. This is recorded in the faculty meeting minutes.

If the action plan results in a change to the catalog description, course prerequisites, or course outcomes, the next time the course is taught the faculty evaluate those changes explicitly. More minor changes are implicity evaluated at the next teaching of the course. During major curriculum revisions, the body of course improvement forms is used to guide revisions. At those revisions, course level improvements are consolidated.

One of the most significant results of implementing course level continuous improvement is the longitudinal documentation of course and curricular development. The overhead cost of documentation is outweighed by breaking the cycle of repeating past mistakes – the faculty appreciate this. Furthermore, securing faculty buy-in is completely dependent on faculty seeing the benefits of their work towards quality improvement.[16] We note that the benefit of satisfying ABET requirements is not sufficient to change the faculty culture. In this case, when course improvements are suggested, documented, implemented, and evaluated, faculty are far more likely to invest in the process.

Program Outcome Assessment and Evaluation

Program outcomes are assessed using a combination of targeted course assessment, senior capstone assessment, and service departments' assessment. The program outcomes are linked to the courses as shown by the example in Appendix 2. Program outcomes are directly assessed on a periodic basis by faculty when teaching the courses indicated with an *'A'* in Appendix 2.

Program outcome assessment is performed by the course instructor. Common tools include special projects, labs, lab reports, project reports, and or specific exam questions. The course

instructor then gauges the attainment of the outcome based on a rubric. The instructor also provides feedback, specifically if the attainment is lower than pre-set thresholds. A typical program outcome assessment form is shown in Appendix 3. Faculty who are teaching courses subject to program outcome assessment are given a blank program outcome assessment form at the beginning of the term. The completed form and relevant student work samples are returned by the faculty for server filing by the department at the end of the term.

The program director evaluates the program outcome assessment data against previous results and pre-established benchmarks. Areas of concern are identified. Subsequently, these areas of concern are discussed in program faculty meetings and possibly at an industrial advisory committee meeting. Action plans are developed and executed where appropriate. The action plan includes the course/curricular changes, a timeline for implementation, and an ongoing assessment evaluation. In some instances, courses that introduce new material relevant to a program outcome may be included in ensuing assessments via the outcome assessment form to measure the performance of the changes. These discussions and decisions are recorded throughout the year in the program meeting minutes.

It has been found that most changes resulting from the program outcome assessment have a significantly longer time constant than changes resulting from the course level continuous improvement. Whereas course level continuous improvement changes may be assessed typically within a year (at the next course offering), program outcome assessment changes may take four years or more to be assessed from the time of implementation. Therefore, the impetus for program outcome assessment changes must be greater to cause such a significant longitudinal investment.

Critical to the overall management of the course level continuous improvement and the program outcome assessment is the annual documentation that summarizes the year's assessment data, effectiveness of past changes, new course and curricular changes, and changes to the assessment and evaluation process. One of the major functions of this reporting is assessing and evaluating the longer-term curricular changes that occur over multiple years. This documentation is described in the next section.

Annual Institutional Assessment Audit

Our university has implemented an institutionally required annual Assessment Audit for every academic program. The purpose for this was driven both by the engineering programs and also by the desire to systematically address assessment in a uniform manner. The university's expertise in assessment was scattered among various individuals across campus. With this institutional effort that expertise was shared among all programs. Further, it would be a mistake to think that assessment is something to consider only if considering an engineering program. All programs benefit if a successful assessment program can be established. A uniform process also tremendously improves the ability of departments to communicate with each other and identify and address shared problems.

The Assessment Audit was patterned after the ABET Engineering Criteria.[11] There are three components of the Engineering Criteria that carry a great deal of common sense for all programs:

1. A program should have educational objectives. They define the purpose of the program, what career paths the graduates ought to successfully be able to navigate, and suggest the kind of preparation that is required for those career path, i.e., they provide a deliberateness to the educational effort of the program.
2. A program should have program outcomes in the form of a knowledge base and defined capabilities of its students at the time of graduation. These are the characteristics and skills that propel graduates forward upon commencing their careers. They should form the basis that will allow the graduates to succeed in fulfilling the educational objectives.
3. A program should have a process that systematically provides both a quantitative and qualitative measure of the success of each program in meeting its intents. The educational arena is a highly competitive one and we want to be known for the high quality of the educational experience we are expected to provide.

The Assessment Audit form is shown in Appendix 4. It requires of each program the following:

- The program educational objectives and outcomes in effect for the prior academic year
- The current version of the program's assessment and evaluation procedure
- A summary analysis of the assessment results that will include a comparison of the metrics of the stated educational objectives and program outcomes to the benchmark metrics established in the assessment and evaluation procedure
- A list of changes to be made, if any, to the program curriculum and the assessment and evaluation procedure based on the assessment results
- A list of issues to be resolved, if any, that require further resources from and/or dialogue with the university administration

The output of the Assessment Audit is a report, encouraged to be brief to assure succinct conclusions. The findings of the report are shared with the faculty of the program and also shared among all departments. The report is critically evaluated by at least two peers from other academic departments on campus. Most importantly, because the primary focus of the process is on the same items required by ABET, the series of such reports over a number of years provides the basis for writing the ABET Self-Study. The latter is a strong incentive for Program Directors who are charged with producing the Self-Study for their program. The reports also establish a baseline for comparing program changes as they occur.

Conclusions

The implementation of the coordinated Continuous Improvement Process has received very favorable faculty reaction. Our participation rate, while always required, now actually is virtually 100%. Further, adjunct faculty are generally a weak link in the assessment chain. The simplicity of our process not only pulls them into the assessment process but also improves their understanding of how the curriculum functions.

Our department consists of five undergraduate and three graduate programs, all reporting to the department chair. For a small university this is a considerable convenience because it allows

sharing of faculty expertise since there is considerable overlap between programs such as computer and electrical engineering, computer and software engineering, and biomedical and electrical engineering. Hence, the faculty – while assigned to individual programs – is also shared between programs. Having a common assessment process is critical for compliance in participation in the process.

One of the challenges has been the collection, coordination, and integration of assessment information from other campus academic departments. The lack of a common process across departments is a primary cause of this challenge. However, it is encouraging to note that there has been recent motion towards adopting major aspects of the process described in this paper by other academic departments.

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APPENDIX 1: Sample Course Improvement Form

EE 4021 021
Principles of Communications
3-2-4
Q1 2010
Faculty Name

Catalog description: In the study of communication systems, students will investigate how they operate and what affects their performance. The course relies heavily on system and signal analysis, both in the time and frequency domains, and on the statistical representation of random signals and noise. Amplitude and angle modulation systems are analyzed, including systems that transfer analog data and systems transferring digital data. Performance comparisons of commonly used digital modulation methods are presented. Signal-processing techniques that are commonly used in systems that transfer digital data are presented. Bit-error rate performance for baseband signal detection in the presence of noise is analyzed. Laboratory experiments reinforce the concepts from the lecture, with an emphasis on communication system functional modules.

Course prerequisites: MA-3620, EE-303 or EE-3031

Course outcomes:

1. develop the representations of analog AM, FM, and PM communication signals both in the time and frequency domains
2. explain the representations of digitally modulated ASK, FSK, and PSK communication signals both in the time and frequency domains
3. analyze communication systems and subsystems (both analog and digital) using both time and frequency domain techniques
4. explain advantages and disadvantages of various modulation systems under differing circumstances
5. determine the performance of AM and angle modulation systems with a specified input signal-to-noise ratio
6. determine required bandwidths and signal-to-noise ratios needed to achieve specified bit-error rates for various digital modulation methods in the presence of noise
7. design an optimal correlation receiver for baseband and bandpass, binary and M-ary, digital communication systems operating in the presence of noise

Deviation from published catalog description and/or course outcomes (if any):

Did not cover SNR for analog systems, BER for M-ary digital systems, or spread spectrum communications – ran out of time.

Course modifications (e.g., topic sequence, catalog description, schedule, etc.) made since the last time you taught the course:

As was planned via discussions with the other course istructor (Dr. XYZ) at the beginning of the course, we chose to omit SNR for analog systems, and very briefly discuss spread spectrum (SS) communications. (I did not get to include the SS discussion – ran out of time – so I will offer an optional seminar on this topic in week-2 of winter, inviting all interested EE seniors.)

APPENDIX 1: Sample Course Improvement Form - Continued

The time at which MA-3620 can be a mandatory prerequisite is very much anticipated. (I believe it will not be until Fall of 2011.) I believe we should provide feedback to the Math Dept. to help the department prioritize some needed items. Maybe some useful feedback would be a set of worked-out problems and a copy of my lecture notes that I use to "review" the material in this area, with special notations added to identify which items in these notes/problem we would like a student to be able to do upon completion of MA3620. I will first run such items past the EE program director and the other course instructor to see if they agree with what I put together. I expect to have that to them by the end of week-2 of Winter 2009-10, and then perhaps have a 1-hour meeting with them in week-3 to review it. Some pertinent information on this is the set of EE-4021 learning objectives I have established in this area, which could also be provided to the Math Dept.:

EE-4021 WEEK-8 LEARNING OBJECTIVES:

1. Describe and sketch probability density functions and probability distribution functions for continuous and discrete random variables.
2. Determine the mean and variance of a random variable given its probability density function.
3. Calculate probabilities for random events (for example, observing three consecutive "heads" in coin flips), given descriptions of the probabilities of related events (for example, the probability of each "head" result is 0.52).
4. Describe the difference between a random variable and a random process.
5. Describe autocorrelation function, power spectral density, and the relationship between the two.

Positive and/or negative reflections on course (including relevant student feedback, if any):

1. It would really help to improve the students' preparation in the probability, random variables, and random processes areas, through (I am suggesting) feedback to the Math Dept. as suggested under the "Proposed actions for course improvement" just above.
2. There appears to be some isue with students needing instruction on how to determine what ought to be included in a "lab report." In EE-4021, an informall, "engineering notebook" format is used for all reports. However, I suspect that the format (engineering notebook or formal laboratory report) would be immaterial. Several students provide little more than the documentation of measured data and (only when explicitly required) "prelaboratory" calculations. In particular, the analysis of lab results and formulation of pertinent conclusions often have shortcomings. The next time I teach this I will try to provide one good example of a report for an electronic communications experiment that will be an experiment that I make up just to show a good report example (not one of the regular EE-4021 experiments).

Check boxes that apply:

- [X] Program director notification needed
- [ ] Course coordinator notification needed

Entries below are for course coordinator and/or program director only.

Action(s) taken by course coordinator:

Action(s) taken by program director:

Plan of action was presented by Dr. XYZ and approved (course coordinator) at program faculty meeting on 1/4/10. Refer to faculty meeting minutes.

APPENDIX 2: Mapping Electrical Engineering Program Courses to Program Outcomes

I=introduced, R=reinforced, A=assessed

Curriculum	Program outcomes											
Course	a	b	c	d	e	f	g	h	i	j	k	l
EE-100	I	I		I					I		I	
MA-136	I											
EN-131							I					
HU-100								I	I	I		
Bus. El. (3 cr)			I					I				
EE-1910	I	I	I		I						I	
MA-137	I											
EN-132							R		I			
CH-200	I	I										
AE-1311			I				I					
EE-2050	I	I			I						I	
MA-231	I											
EN-241							A		A			
EG-1260							I					
PH-2010	I	I										
EE-2060	R	R			R						R	
EE-2920	R	R	R		R		I				R	
MA-235	R											
PH-2020	R	R										
EE-2070	R				R						R	
EE-2930	R	A	R		R		I				R	
EE-2900	I	I	I	R	I						I	
MA-232	R											
PH-2030	R	R										
EE-2902	R	R	R	R	R						R	
CS-2510	R		R									
MA-383	R											
ME-255	R				R							
ME-354	R				R							
EE-3050	A				R						R	
EE-3101	R	R	R	R	R		R				A	
EE-3921	R	R	A	R	R		R				R	
IE-423			R					R				
SS-461						I			R	R		
EE-3111	R	A	R	R	R		R				R	
EE-3202	R				R							
EE-3220	R	R		R	R						A	
EE-3720	R	R	R	R	R		A				R	
GE-300						A	R		A			
EE-3031	R				A							
EE-3212	R	R		R	A						R	
EE-3401	A	R		R	R		R				R	
MA-3620	R											I
EE-407	R		R	A	R	R	R	A	R	A	R	
EE-4021	R	R		R	R		R				R	A
PH-360	R											
EE-408	R	R	A	A	R	R	A	R	R	R	R	
EE-409	R	A	R	R	R	A	R	R	A	R	R	
HU-432						A		A	A	A		
HU/SS (15 cr)								A	A	A		
Tech El (12 cr)	R		R		R						R	
Sci El (3 cr)	R											

APPENDIX 3: Sample Program Outcome Assessment Form

EE Program Outcome Assessment Summary

Course Number: **EE3401** Section #: **1**

Quarter/Year Taught: **Spring 2008** Instructor Name:

Program Outcome Assessed: (a) an ability to apply knowledge of mathematics, science, and engineering

(a) an ability to apply knowledge of mathematics, science, and engineering

Briefly describe the tool(s) used (e.g., exam question(s), laboratory report(s)). Please submit graded, paper-version high/medium/low examples to EE Program Director.

Final exam questions 2, 4, 5

64% of students scored 3 or 4 in the skill set described by the program outcome.

Recommendations for improving student performance, if applicable. Any other comments.

Except in 2 instances, all students were able to substitute the given quantities in the formula and obtain numerically correct answer with correct units. All of the students scoring 1 were unable to name the Faraday's law of induction. All of the students scoring 2 or less were unable to provide a simple mathematical expression of the Faraday' law. The recommendation is to increase the emphasis on the link between the fundamentals laws of physics, specifically electromagnetism, and the practical engineering formulas by demonstrating and testing student's ability to execute simple derivations - this would help integrate their knowledge of science, math, and engineering.

In the table, enter an X for each student that corresponds to your assessment of their competence in the program outcome. The table computes the percentage of answers in the 3 and 4 categories.

Student #	0	1 Some effort beyond restating the problem or copying given data; little understanding of the problem; failure to address most aspects of the problem; major flaws in reasoning that lead to invalid conclusions	2 Gaps in understanding and/or execution; incomplete understanding of the problem; fails to address some aspects of the problem; faulty reasoning; weak conclusions	3 Demonstrates understanding of the problem; contains minor flaws; communicates adequately through writing and/or diagrams; generally reaches reasonable conclusions; may show minor flaws in reasoning and/or computation; may neglect some aspects	4 Shows complete understanding of the problem; demonstrates an effective solution; thoroughly addresses all points relevant to the solution; shows logical reasoning and valid conclusions
1					X
2					X
3			X		
4					X
5		X			
6					X
7				X	
8				X	
9		X			
10			X		
11				X	
12			X		
13					X
14					X
15					
16					
	0	2	3	3	6

APPENDIX 4: Program Assessment Process Audit Form

The purpose of the audit form is to provide assurances that every program has:

- A fully implemented assessment process – from the defining of objectives and outcomes to implementing changes resulting from the analysis of assessment data.
- A periodic review of the assessment process itself as to its suitability to provide data relevant to properly assess the program objectives and outcomes.

It is the responsibility of the program to define the appropriate program objectives and outcomes, as well as an assessment process, to assure they are in keeping with the accreditation process relevant to the program and in keeping with the Institutional Learning Outcomes.

SECTION 1: To be completed by the Program Director (or Assessment Coordinator)

Name of Program _____

Program Director _____

Audit for AY _____

Audit Date _____

A. Program Educational Objectives in effect during the last AY – Attach as **Appendix 1**

Last updated/reviewed by program faculty (date) _____

The primary constituents of the program are:

	Constituents	Consulted on Objectives (Yes/No)	When
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____

B. Program Outcomes in effect during the last AY – attach as **Appendix 2**

Last updated/reviewed by program faculty (date) _____

C. Program has an Assessment Plan – Attach as **Appendix 3**

a. Yes _____ No ____ Last updated/reviewed by program faculty (date) _____

b. In the appendix list any improvement(s) needed in the assessment plan/process itself and how that is being addressed. The intent is to assure the relevance of the plan in assessing the specific current program objectives and outcomes.

D. Assessment methods/tools used for the program **Educational Objectives** - provide for each objective (as **Appendix 4A**):
    a. List of the direct assessment methods/tools used
    b. List of the indirect assessment methods/tools used

E. Assessment methods/tools used for the **Program Outcomes** - provide for each outcome (as **Appendix 4B**):
    a. List of the direct assessment methods/tools used
    b. List of the indirect assessment methods/tools used

F. Provide as **Appendix 5** a concise ***EXECUTIVE SUMMARY*** of the results-of your assessment process.

The complete Executive Summary is to be NO LONGER THAN 2 PAGES.
If needed, additional material can be attached as Appendix 6.

The summary should appropriately address items such as:

- Clearly distinguish between program objectives and program outcomes
- Include SAMPLE assessment data demonstrating the process was implemented
- List needed program improvement(s) uncovered by the assessment process
- Assessment methods/tools used to identify the needed improvement(s)
- Details demonstrating implementation of any program improvements
- Results of assessing the implemented solution

SECTION 2: To be completed by the audit reviewers

A. Program Audit Results

	Needs Improvement	Acceptable	Exemplary	Reviewer Comment #
Program Educational Objectives	☐	☐	☐	_____
Program Outcomes	☐	☐	☐	_____
Assessment plan	☐	☐	☐	_____
Assessment plan implementation	☐	☐	☐	_____
Assessment plan – periodic review	☐	☐	☐	_____
Collection and analysis of data	☐	☐	☐	_____
Implementation of program changes	☐	☐	☐	_____
Evaluation of program changes	☐	☐	☐	_____

Reviewed by _____ (print) Date _____

Reviewed by _____ (print) Date _____

B. Reviewer Comments (List comment number in Section 2.A) and Recommendations: