Development and Implementation of an ABET-Compliant Course Profile & Assessment Model

Heidi A. Diefes, Kamyar Haghighi
Purdue University

Abstract

As part of the ABET assessment process, each course in an accredited program must be evaluated for ABET compliance by the teaching faculty. By establishing an ABET compliant course profile and assessment model, program deficiencies between expected program outcomes and actual course level outcomes can be identified. The Department of Agricultural and Biological Engineering at Purdue University has developed a three-step model. First, the assessment process, program outcomes and performance criteria are developed and adopted by the faculty. Second, each teaching faculty member evaluates his/her own course(s) by reducing course syllabi down to course learning objectives and a list of major topic areas and practices. The level to which the course addresses each performance criteria is estimated using a Bloom's Taxonomy scale. Third, all course profiles are compiled and analyzed to pinpoint strengths and weaknesses in particular performance criteria or outcomes. This paper will highlight the ABET-compliant course profile development and implementation and a model for program deficiency analysis.

Introduction

One can look at the conference proceeding for any engineering professional society and see that much thought, discussion, and effort has gone into interpreting what ABET means by assessment process, program educational objectives, and program outcomes. However, the details of how to conduct an assessment and evaluate the vast amount of data generated by students, faculty, employers, and alumni are much more difficult to cull from the literature. A case-in-point is how should a program's courses be evaluated for ABET compliance using the instructors' perspectives?

Before delving into the details of the ABET-compliant course profile and assessment model developed by the Department of Agricultural and Biological Engineering (ABE) at Purdue University, the terminology and assessment process being adopted by ABE need to be introduced. The terminology defined in Table 1 and assessment process delineated in Figure 1 are being used in two ABET accredited programs, Agricultural and Biological Engineering (ABE) and Food Process Engineering (FPE). The two looped educational assessment process mirrors the two loops of EC2000 [1]. In the outer 3-5 year loop, the process allows constituents to provide input to and feedback on each ABE program. The faculty integrates this information into the ABE mission and vision statements, educational objectives, program outcomes (PO), performance criteria (PC), and, ultimately, the curriculum. The inner loop of the process focuses on course level evaluations and analysis of student and graduate performance followed by an assessment of gaps between the expected and actual student achievement levels. The loop is closed with a mechanism for instituting change to improve the program both in the long and short term.

Table 1. ABE & FPE Educational Assessment Process Terminology (*draft*).

ABE Terms	Acronym	Working Definition
Educational Objective	--	A broad, yet department specific, statement of how an academic program will satisfy constituency needs and the educational mission [2].
Program Outcome	PO	A broad description of what a graduate will be expected to know and be able to do after completing an academic program [2]. A PO is not directly measurable.
Performance Criteria	PC	A specific understanding, ability, or skill that a graduate will be expected to have upon completion of a curriculum. A PC is directly measurable.
Course Learning Objective	CLO	A series of statements describing the knowledge or skill a student is expected to acquire during a course.

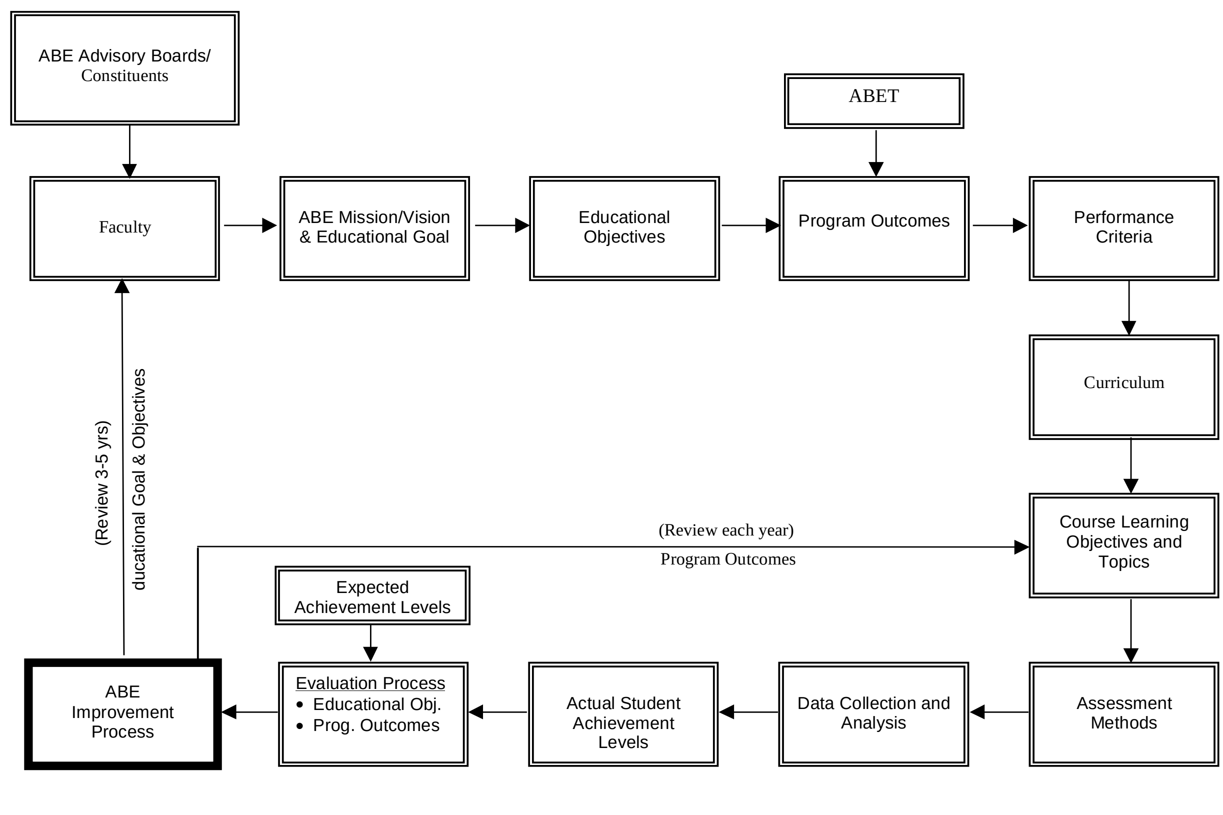

Figure 1. ABE & FPE Educational Assessment Process (*draft*)

The program outcomes describe, in a general way, the abilities and skills of graduates of the program and encompass, but are not limited to, the ABET Criterion 3 (a) through (k) [3]. Program outcomes follow directly from the educational objectives which state how the program intents to fulfill its mission. The program outcomes for the FPE program are listed in Table 2. Performance criteria in essence provide details about the types of abilities and skills expected of graduates for each program outcome; they are measurable. Examples of the performance criteria for POs 2 and 10 are shown in Table 3. Once program outcomes and associated performance criteria have been established, all of the courses that comprise the curriculum should be evaluated for ABET compliance by the teaching faculty. This is a first step towards realizing the deficiencies in a program and the gaps that may exist between the expected outcomes and the actual course level outcomes. The relationship between program outcomes, performance criteria and course learning objectives, topics, and practices must be established to develop an ABET-compliant course profile. The lack of published or available material on methods employed to establish this relationship makes this step in the development of the assessment process a seemingly insurmountable hurdle. After a considerable pioneering effort, the ABE has developed an ABET-compliant course profile and assessment model.

Table 2. FPE Program Outcomes (*draft*).

Graduates of our program will demonstrate:	
Basic Engineering Skills	
1.	an understanding of the fundamental principles of mathematics and science;
2.	an understanding of food process engineering principles;
3.	the ability to design and/or conduct experiments and analyze food systems and processes;
4.	an understanding of, and the ability to, identify, formulate, model and solve problems for food process engineering systems;
5.	the ability to design a system or process to meet desired needs in the area of food process engineering;
6.	effective use of appropriate techniques, skills, and state-of-the-art engineering tools necessary for engineering practice;
Professional and Personal Skills	
7.	an understanding of the global and societal impact of engineering practice, research and discovery;
8.	a knowledge of contemporary issues;
9.	appropriate and effective writing, speaking, and listening skills;
10.	the ability to function on, and contribute effectively to, a multi-disciplinary team;
11.	the ability to understand and practice ethical responsibility in personal and professional life;
12.	an appreciation for the value of life-long learning to maintain “life-balance” and achieve maximum potential.

Table 3. Performance Criteria for Program Outcomes 2 and 10 for the FPE Program as Marked for ABE 210 Course Profile (*draft*).

Outcome 2: An understanding of food process engineering principles.

Performance Criteria Students will have the ability to:	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Valuation	Not Applicable
1. Use the mathematical relationships and models to describe food and biological engineering systems	■	■	■					
2. Apply thermodynamic principles to predict equilibrium behavior of chemical, physical, and biological systems	■	■	■					
3. Use constitutive and rate equations to model physical, chemical, and biological processes	■	■	■					
4. Predict the effects of physical / chemical / biological properties on food processing systems								X
5. Apply engineering principles to model / simulate the dynamics of a process								X

Outcome 10: The ability to function on, and contribute effectively to, a multi-disciplinary team

Performance Criteria Students will have the ability to:	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	Valuation	Not Applicable
1. Brainstorm	■							
2. Initiate and maintain task-oriented dialogue								X
3. Set team goal(s)								X
4. Work for constructive conflict resolution	■							
5. Utilize effective project and time management skills	■	■						
6. Strive for meaningful group consensus								X
7. Assess success of the project and team members' contributions								X

As a starting point for program assessment, a clear picture of the curriculum must be developed from course level information. This evaluation should answer such questions as:

- What topics are being taught?
- What practices are being employed to engage students in learning?
- What are the course learning objectives?
- Are all program outcomes being addressed?
- To what level are performance criteria being met?
- Do these levels match the targeted levels?

The remainder of this paper will focus on how this information is extracted from the teaching faculty and how it can be used to systematically identify deficiencies in a program.

Course Profiles

It is the responsibility of each teaching faculty member to develop a course profile for each course the individual teaches. A partial blank profile is given in Table 4. To complete a course profile, the ABE faculty completed the tasks outlined in Table 5.

Table 4. Template for ABET–Compliant Course Profile (*draft*)

Course #:
Course Title:
Instructor:

Course Learning Objectives:

Successful completion of the course will enable the students to:

1.
2.
3.

Course Topics/Practices:

1.
2.
3.

Relationship Of Course Learning Objectives (CLO) To FPE Program Outcomes (PO) and Performance Criteria (PC):

CLO	PO	PC

Table 5. Tasks to Complete an ABET Compliant Course Profile.	
1.	List course topics and practices
2.	Develop course learning objectives (CLOs)
3.	Establish the relationship between the CLOs and the POs
4.	Establish the relationship between the CLOs and the course topics
5.	For each performance criteria (PC), mark the appropriate box that corresponds to the highest Bloom's level of coverage for the course.
6.	Tabulate the relationships between CLOs, POs, and PCs.

To demonstrate this six-task process, the development of a course profile for ABE 210 – Biological Applications of Material and Energy Balances (Introduction to Thermodynamics) will be used as an example. The first task entails the listing of the topics and practices for the course. The course topics and practices for ABE 210 are shown in Table 6.

Table 6. Course Topics and Practices for ABE 210 and their Relationship to the Course Learning Objectives (CLO) (*draft*).	
1.	First law of thermodynamics (mass and energy balances) (CLO 1,2)
2.	Second law of thermodynamics (entropy balances) (CLO 1,2)
3.	Thermodynamic cycles (e.g. power and refrigeration cycles) (CLO 1,2)
4.	Group design projects focused on Food Process Engineering thermodynamics problems (CLO 1-5)
5.	Computer skills building exercises centered on thermodynamic problems (CLO 4)

Practices are included in this list primarily to capture activities that contribute to the development of non-technical skills. In this case, group design projects is a course practice that contributes to the development of good writing skills and exposes students to teaming in the context of design.

The second task in the development of a course profile is the writing of course learning objectives (CLOs). The CLOs describe in a general way the skills that students are expected to acquire as a result of successful completion of the course. Table 7 lists the CLOs for ABE 210.

Table 7. Course Learning Objectives for ABE 210 and their Relationship to the Program Outcomes (PO) (*draft*).	
The successful completion of ABE 210 will enable students to:	
1.	Understand the basic principles of material, energy, and entropy balances (PO 1,4)
2.	Understand applications of energy and entropy balances to power, refrigeration, and biological systems (PO 1,4)
3.	Apply thermodynamics concepts/functions to the design of agricultural and biological engineering systems (PO 2,3,5,6,9,10)
4.	Use computers to solve material and energy balances and thermodynamic problems (PO 6)
5.	Write clear, concise design summaries (PO 9)

The third and fourth tasks establish the relationships between the course topics and practices and learning objectives and the program outcomes and performance criteria. First, a link is made between the course learning objectives (Table 7) and the program outcomes (Table 2). For each CLO, a list of POs that the CLO addresses is generated and noted at the end of each CLO as in Table 7. For instance, CLO 1 which deals with the basic principles of thermodynamics addresses PO 1, demonstrate an understanding of the fundamental principles of mathematics and science, and PO 4, demonstrate an understanding of, and an ability to, identify, formulate, model, and solve problems for food process engineering systems. In a similar fashion, each course topic and practice (Table 6) is linked to one or more course learning objective (Table 7). Here, the first course topic addresses CLOs 1 and 2 (Table 6).

For the fifth task, the instructor estimates the degree to which the course addresses each performance criteria. Bloom’s Taxonomy is used as the scale where the lowest level of skill attainment is Knowledge and the highest level is Valuation [4]. For each program there are 12 POs with 2-8 PCs per PO. FPE POs 2 and 10 with associated PCs (Table 3). The grayed bars indicate the levels to which ABE 210 addresses each performance criteria. Note that not all performance criteria are addressed by every class, as indicated by the 'X' in the Not Applicable column.

The final task ties a number of the components of the profile together in one summary table. Table 8 shows how CLOs for ABE 210 relate to the POs and the PCs. A given CLO may address multiple POs but only certain PCs for a given PO. For instance, CLO 3 addresses PO 2 but only PCs 1,2 and 3.

Table 8. Relationship of CLOs to POs and PCs for ABE 210 (*draft*).

CLO	PO	PC
1	1 4	1,2 4
2	1 4	1,2 4
3	2 5 9 10	1,2,3 1,2,3,4,5,8 1 1,4,5
4	6	2
5	9	1

Pieces of the course profiles are fed into the course syllabus used as evidence to satisfy ABET Criterion 4 (Professional Component) and Criterion 8 (Program Criteria). A sample course syllabus is given in Table 9.

Program Deficiency Analysis

Once course profiles have been developed for each course in a program, the profiles can be compiled to give a picture of the curriculum with a high degree of resolution. One possible way to analyze the data is to study each performance criteria individually. The plots in Figures 2 and 3 show faux data for two different program outcomes and performance criteria. On the x-axis is the list of core courses in the FPE curriculum starting in the sophomore year. The y-axis

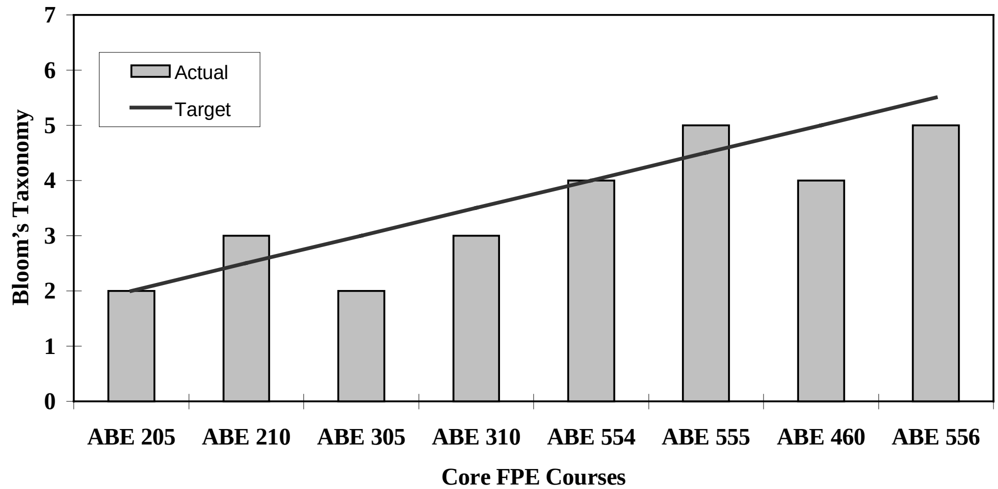

Figure 2. Faux compiled profile results for FPE PO 2: An understanding of food process engineering principles; PC 1: Use mathematical relationships and models to describe food and biological engineering systems.

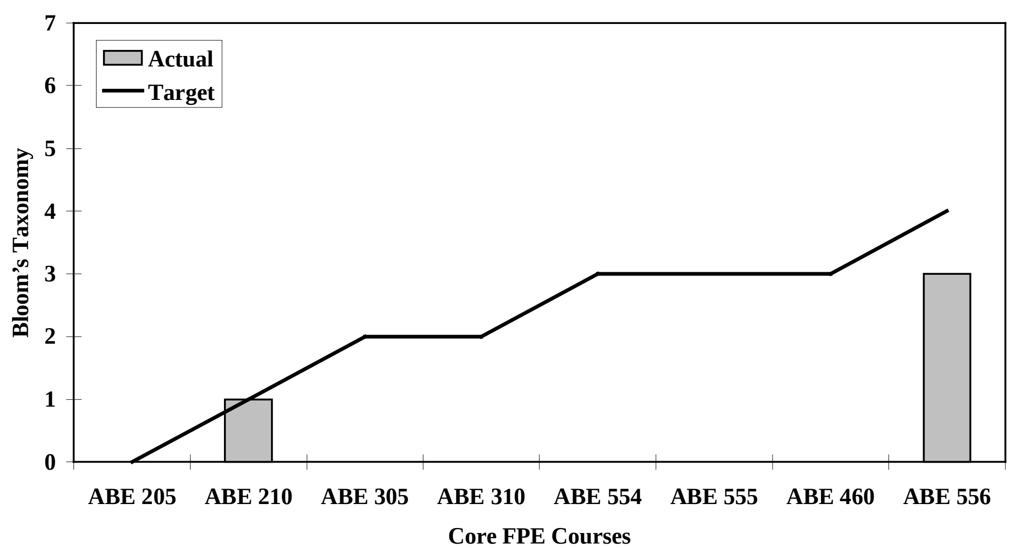

Figure 3. Faux compiled profile results for FPE PO 10: The ability to function on, and contribute effectively to, a multi-disciplinary team; PC 1: Brainstorm.

Table 9. Sample Course Syllabus (*draft*).

ABE 210: Biological Applications of Material and Energy Balances

1. 1999-2000 Catalog Description

Sem. 2. Class 2, lab. 2, cr. 3. Prerequisite: CHM 116, CS 152, PHYS 152, or equivalent. Applications of material and energy balances to biological and engineering systems; development of a framework for the analysis of biological systems from an engineering perspective. Introduction to applications of the first and second laws of thermodynamics to biological and mechanical engineering systems. Topics include refrigeration systems, power cycles, energy conversion systems, and environmental impacts of energy production.

2. Prerequisite(s)

CHM 116, CS 152, PHYS 152, or equivalent.

3. Textbook and/or other required material

Fundamentals of Engineering Thermodynamics, Moran & Shapiro, Wiley

4. Course Learning Objectives

Successful completion of the course will enable the students to:

1. Understand basic principles of material, energy, and entropy balances (PO 1,4)
2. Understand applications of energy and entropy balances to power, refrigeration, and biological systems (PO 1,4)
3. Apply the basic thermodynamic concepts/functions to the design of FPE systems (PO 2,5,9,10)
4. Use computers to solve material and energy balances and thermodynamic problems (PO 6)
5. Write clear, concise design summaries (PO 9)

5. Course Topics

1. First Law of Thermodynamics (Mass and energy balances) (CLO 1,2)
2. Second Law of Thermodynamics (entropy balances) (CLO 1,2)
3. Thermodynamic cycles (power and refrigeration) (CLO 1,2)
4. Group design project(s) focused on FPE thermodynamic problems (CLO 1-5)
5. Computer skills building exercises centered on thermodynamic problems (CLO 4)

6. Class/Laboratory Schedule (number of sessions each week and duration of each session)

Three class sessions each week @ 50 minutes for each session. There are no formal labs.

7. Contribution of Course to Meeting the Professional Component

This course provides 2 credits of engineering science (or engineering topics) towards Criterion 4b.

8. Relationship of Course Learning Objectives (CLO) to Program Outcomes (PO)

CLO	PO
1	1,4
2	1,4
3	2,5,9,10
4	6
5	9

9. Prepared by: **Heidi Diefes** **Date:** **November 10, 1999**

represents the faculty's assessment of the levels to which their courses build the indicated skill or ability in the students.

The levels to which performance criteria are being achieved need to be compared with faculty established target values. The line on Figures 2 and 3 represent possible target achievement levels. The faux results in Figure 2, indicate that the FPE program is nearly on track for PO 2, PC 1. However, in Figure 3 a flag would be raised since there is a considerable and consistent gap between the target and actual level for PO 10, PC 1. The faculty would need to follow this assessment up with a discussion of how and in which courses to strengthen deficient parts of the program and implement change to better achieve the program outcomes.

Faculty Involvement, Challenges, and Conclusions

In ABE, the Academic Programs Committee has been charged with taking the lead in developing an educational assessment process and educating the faculty and eliciting constituent and faculty input to the process. Faculty engagement in the process of developing program outcomes, performance criteria, and course profiles was facilitated by a two training workshops and a number of program or cluster meetings. During the first workshop, the faculty was formally introduced to ABET EC 2000 and a proposed assessment process for ABE programs. A draft set of program outcomes and performance criteria was used to stimulate initial discussions. Following this workshop, each program cluster in ABE met to finalize the program outcomes and performance criteria.

The second workshop focused on training the faculty to develop course profiles. During this second workshop, it was evident that a number of challenges will face ABE during the compilation of the course profiles. First, the faculty provided different amounts of detail in their list of the course topics and practices. Second, the faculty used inconsistent language in the course learning objectives. Third, there was varying interpretations of Bloom's Taxonomy and a tendency towards over-estimating achievement of perfomance criteria.

It is felt that the compilation of the course profiles will provide a wealth of information about the state of the ABE programs. However, the challenges encountered will necessitate a number of iterations of course profile development as the faculty becomes more accustomed to the assessment process.

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HEIDI A. DIEFES
Heidi A. Diefes is an Assistant Professor of Freshman Engineering at Purdue University with a joint appointment in the Department of Agricultural and Biological Engineering. She serves on the ABE Academic Programs Committee

which has taken the lead in educating the faculty about the ABET assessment process. She received her B.S. and M.S. in Food Science from Cornell University and her Ph.D. from ABE in 1997.

KAMYAR HAGHIGHI
Kamyar Haghighi is a Professor in the Deptartment of Agricultural and Biological Engineering at Purdue University. He is the Chair of the Academic Programs Committee and is currently leading and coordinating the departmental efforts to prepare for EC 2000 and ABET 2001 review. He received his M.S. and Ph.D from Michigan State University.