Optimizing an Introduction to Environmental Engineering Class for ABET 2000

Charles D. Turner
Darrell C. Schroder
College of Engineering
University of Texas at El Paso
El Paso, Texas 79968

Abstract
The core of the ABET 2000 criteria includes an outcomes driven curriculum and an assessment component with feedback mechanisms for continuous improvement. For the analysis presented in this paper the ABET A-K criteria are grouped into four more general classifications that allow the criteria to be used for individual course analysis and comparison with other courses in the curriculum. The classifications are (1) engineering analysis, (2) engineering design, (3) social responsibility, and (4) communication skills. These classifications are used to analyze the performance of an Introduction to Environmental Engineering (IEE) course with and without a laboratory for meeting ABET 2000 criteria. The use of four classifications allows the use of graphical techniques such as radar analysis to compare performance using various course options.

I. Background

The University of Texas at El Paso College of Engineering's ABET 2000 Committee is preparing for their scheduled 2001 visit. The authors are members of this committee. Different methods for evaluating courses under the ABET 2000 criteria have been discussed. The methodology outlined in this article is designed to provide a quantitative method for comparison of options for changes within a course as well as a comparative basis for different courses. The IEE course is used as an example of how this methodology works.

Discipline specific introductory courses such as an Introduction to Environmental Engineering play an important role in meeting the new criteria because they offer the flexibility of content and the ability to experiment that core courses do not. Specifically, the ABET 2000 criteria specifies that graduates be able to understand the impact of engineering solutions in a global and societal context and to have a knowledge of contemporary issues. The Introduction to Environmental Engineering (IEE) course allows the coupling of fundamental science with engineering design to address local and global problems. Engineers have always found solutions to problems that were appropriate in the context of the times. Some of these solutions are viewed by society as problematic today. Classic examples include dams and urban transit systems. Finding engineering solutions for today's problems that make possible a better future for coming generations is a contemporary "sustainability" theme that fits well into an IEE course.

Introduction to Environmental Engineering is a three credit hour junior level class that has undergone continual change. The class reflects changes within the profession of environmental engineering. The current catalog description of the course is as follows :
"Introduction to the engineering aspects of environmental systems to include such topics as water quality management, air pollution and control, solid and hazardous waste management, environmental impact assessment, and governmental regulation ".

Elective courses such as IEE are good test beds for assessing the impact of course modifications on ABET's A-K assessment criteria because they are electives and content is flexible within broad boundaries.

II. Methodology and Results

The eleven criteria that make up ABET's A-K list can be classified under four broad headings. These classifications are (1) engineering analysis, (2) engineering design, (3) social responsibility, and (4) communication skills. Table 1 shows how each of the eleven individual criteria can be placed into one of four classes.

Table 1. Classification of ABET Criteria into Four Rational Divisions

Classification	ABET criteria (A-K)
Engineering Analysis	items A, E, K
Engineering Design	items B, C
Communication Skills	items D, G
Social Responsibility	items F, H, I, J

The individual criteria are given in Table 2. Table 2 is an adaptation of the University of Arizona's ABET 2000 criteria Course Classification Form found at their web site http://www.sie.arizona.edu/ABET. A "not applicable" category has been added to the level column . A course with a high level of content for the criteria being evaluated scores three, a medium scores two, a low scores one and a "not applicable", zero. Relevant activities are listed for the IEE class. The first column shows scores for the class without a laboratory and second column shows scores for the class with a laboratory. An obvious example of the numerical assignment for each of the categories is criteria C "Ability to design and conduct experiments and interpret data" where the course with the laboratory is listed as scoring 3 while the course without is given a "not applicable" rating. Numerical scores assigned to each of the criteria are relative and a basis for assigning these scores needs to be determined. The scores assigned in this list are based on the authors' judgement and discussions with other faculty as well as the college's 2001 committee. Once the individual scores have been assigned they can be totaled for comparison with other courses. The totals in Table 2 are within one point of each other. The laboratory version of the class scored 23 as compared to 22 for the non laboratory class. Slightly different numerical evaluations could give a significantly higher number for the laboratory version of the class.

Table 2. Numerical analysis of course content using ABET A-K criteria				
Outcome Criteria		H,M,L,na		**Relevant Activities**
Alternative A is without laboratory		Alt A	Alt B	Alternative B is with laboratory
a.	Apply math, science and engr. principles	2	2	materials balances, steady steady state systems with conservative & non-conservative pollutants, growth models, kinetics
b.	Ability to design and conduct experiments and interpret data	na	3	lab experiments, field work
c.	Ability to design a system, component, or process to meet desired needs	3	2	design project, text problems
d.	Ability to function on multi disciplinary teams	2	1	class open to science majors, informal and formal team assignments, class exercises
e.	Ability to identify, formulate, and solve engineering problems	3	2	textbook problems, local applications, special assignments,
f.	Understanding of professional and ethical responsibility	2	2	current events, speaker, design problem situations,
g.	Ability to communicate effectively	2	3	problem presentations in class, design project team presentations
h.	The broad education necessary to understand the impact of engineering solutions in a global context	3	2	global problems, local impacts, local contributions, interconnects
i.	Recognition of the need for and an ability to engage in life-long learning	1	3	technology applications & changes, multi disciplinary aspects of solutions
j.	Knowledge of contemporary issues	3	1	local newspaper clippings, national news magazines, web searches
k.	Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	1	3	lab & computer applications, models, spreadsheets, web work
	TOTALS	22	23	

Table 3 summarizes the totals for each of the classifications. The totals in this Table 3 are more useful because the relative areas of emphasis for the laboratory versus non-laboratory course are very different. The laboratory class shows a heavier emphasis on engineering analysis and engineering design than the non-laboratory class. While the tables provide valuable information they do not provide the visualization that the mind needs to get a better mental picture of what the numbers mean.

Table 3. Evaluation of IEE course using Rational Classification Criteria			
Classification	ABET criteria (A-K)	without Lab	with lab
Engineering Analysis	items A, E, K	6	7
Engineering Design	items B, C	3	5
Communication Skills	items D, G	4	4
Social Responsibility	items F, H, I, J	9	7
	Totals	22	23

Course Analysis Using ABET Criteria

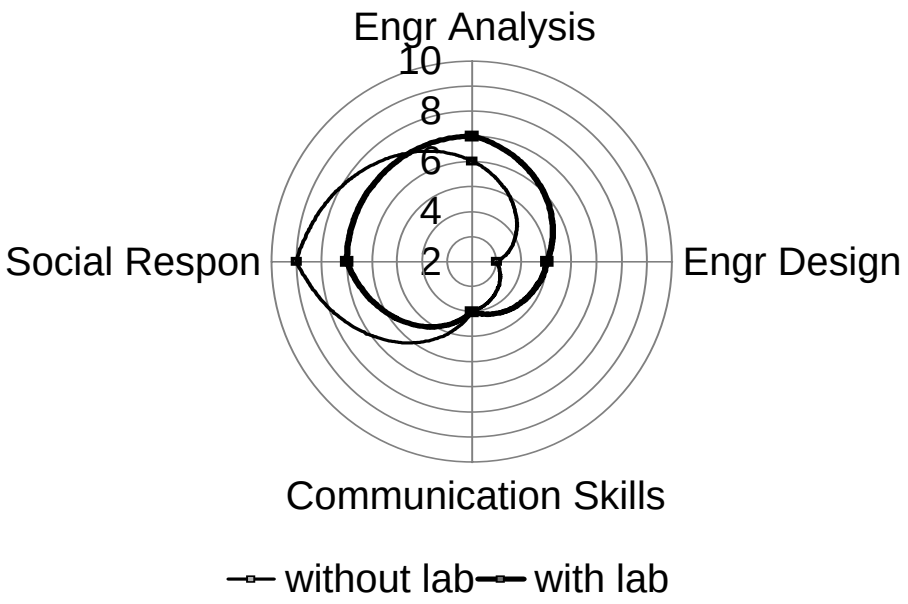

Figure 1. Analysis of Introduction to Environmental Engineering Class with and without a laboratory using ABET criteria

Figure 1 is a "radar graph" of the classification system which shows the differences visually between the course with and without the laboratory. The IEE class without the laboratory has a much higher emphasis on social responsibility. The laboratory course shows a more balanced diagram which indicates a better balance of all criteria.

III. Conclusions

The proposed "rational classification" method allows individuals or groups who wish to evaluate their classes using ABET 2000 A-K criteria a numerical method that simplifies the task and allows visualization of the data. This method is a powerful tool for evaluating options within courses as well as for comparison of courses for meeting ABET 2000 criteria.

Charles D. Turner
Charles Turner has managed a wide variety of environmental research projects that have involved working with interdisciplinary teams and governmental agencies. Dr. Turner served as chairman of the Civil Engineering Department at UTEP from August 1990 to September, 1994. Prior to coming to UTEP, Dr. Turner spent eight years at the University of North Dakota managing the environmental engineering program and conducting interdisciplinary research on the biological treatment of synfuel wastewater in cooperation with the Energy and Environmental Research Center in Grand Forks, North Dakota.

Darrell C. Schroder
Darrell C. Schroder is Assistant Dean for Academics in the College of Engineering and a Professor in the Department of Electrical Engineering. He is author of the text entitled *Introduction to Engineering and Technology*. He is active in the retention activities and works continuously on new technology to improve experimental laboratory methods and learning.