A Process for Developing and Implementing an Assessment Plan in Chemical Engineering Departments

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I. Introduction

The assessment requirements imposed by the new ABET Engineering Criteria 2000 [1] initially appear daunting. Even the terminology is initially confusing. Compounding the challenge is that engineering faculty typically lack experience in conducting outcomes assessment. Several authors have made analogies between the outcomes process of assessment and chemical process control loops [2,3]. Although these may be useful analogies for defining the purpose, they may not provide many specific ideas on how to approach such a large and ill-defined problem as program assessment. No matter how hard we try, we cannot use Laplace transforms and transfer functions to make our problems go away. Instead, we must recognize that we must face these new challenges head on.

The University of North Dakota was slated to be a pilot program for re-accreditation review under Engineering Criteria 2000 in the fall of 1997. Unfortunately, the massive flooding of the nearby Red River of the North in the spring of 1997 caused the accreditation visit to be postponed for one year. Although the flood was devastating to the city, the University, and the houses of the faculty, it did save us from going up for accreditation prematurely. We were not ready!

We had spent time rewriting mission statements and asking ourselves how do we know whether our students are really learning. Like most programs, we saved everything: tests, final exams, lab reports, homework assignments, journal entries, etc. However, we still had no real plan as to what we should do with them. With the extra time, we began a series of discussions, planning sessions and activities that helped us finally address the pivotal issues. In the fall of 1998, the Chemical Engineering program at the University of North Dakota was fully accredited under Engineering Criteria 2000. The site visit culminated a year-long process of preparing and implementing an assessment plan.

We wanted to write a paper that provided practical suggestions that may not appear in a manual. The remainder of this paper is devoted to providing answers to questions that we struggled with and to providing advice for other departments
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II. Questions

1) How do we get started?

Schedule a relaxed meeting that does not occur during normal school hours or take place in your usual, more stressful surroundings. Use this meeting to discuss the steps and develop a timeline. Much of the accreditation and assessment preparation is sequential. Therefore, you will create your timeline for activities by noting your ultimate deadline for submitting your self-study to ABET (i.e., June 1 prior to your accreditation visit) and working your way backward to the present. The major phases are:

a. Selecting and writing about: vision, mission, goals, objectives, outcomes, indicators, practices, assessment methods, and assessment criteria;
b. Discussing and writing the self-study report;
c. Designing, pilot testing, and administering your assessment tools or collecting other data for assessment purposes
d. Collecting materials for the various appendices to the self-study report
e. Analyzing collected data;
f. Making changes to the educational experience based on your findings; and
g. Assessing your improvements.

We cannot provide a timeline for you, since all programs are different. Remember that you will need to have at least one complete cycle before your accreditation visit, so you must be done planning at least one year before the visit.

2) Should we get help?

Yes. Although assessment is worth it, it does add to already overburdened faculty workloads. Therefore, we hired an accreditation/assessment consultant who kept us on pace and helped translate the assessment speak into ideas that we could understand. The consultant should not make decisions for you, but rather should serve as a facilitator in your efforts. The wife of one of our faculty holds a Ph.D. is higher education administration and had several years of assessment experience, so finding a consultant was easy for us. However, almost all universities have a potential consultant in place. Some university personnel have been doing assessment for years. If you cannot afford (or do not prefer) an external consultant, try talking to individuals within your institutional research department or your college of education who may be able to recommend cost-effective assistance.

3) What do all these terms mean?

We recommend you develop a set of common terms and definitions early so that you will know what everyone else is talking about. **Vision** statements outline your mission of the future. **Mission** statements outline the purpose of your program. **Goals** are the lofty aims. Things like "we want our graduates to be effective communicators" are goals. You may wish to include university and college goals with your program goals. **Objectives** are more specific. Perhaps things like "When giving an oral presentation, our students will a) provide an introduction appropriate for a given audience, b) speak clearly, c) present facts in a logical manner, d) support their arguments with facts and data, and e) clearly summarize key points. **Outcomes** tell us what specific result(s) will occur such as "Students will write effective documents." **Indicators** are the specific items to which a "yes" or "no" answer to the outcomes questions can be applied such as "Is the document formatted correctly?" **Practices** are opportunities in your educational experience for student learning such as a class or an activity. **Assessment Methods** are the actual tools or other data collection techniques you use to assess student learning such as portfolios, alumni surveys, the Fundamentals of Engineering Exam, etc. Finally, **assessment criteria** are the stated levels of performance for each assessment method that will be used to guide decisions and set priorities for improvement. You will want to develop ideas that are unique to your program and highlight your strengths in addition to ideas required by outside bodies.

4) How can we make sure all of us are addressing criteria that we need to address?

Use various matrices to give you visual pictures of how your outcomes map to your curriculum and also to your assessment methods. You should try to make sure there are at least three "hits" for every item in the rows and columns for each matrix. On the other hand, if there are too many "hits" in a row or column, you may be able to eliminate some in favor of addressing other desired areas. Two sample matrices are shown in Figures 1 and 2.

5) How much data should we accumulate?

If you save every exam and homework assignment, you will be buried with so much data that you will be unable to figure out what is meaningful. By planning carefully in mapping instruments to your objectives, you can reduce the data collection considerably. Remember, assessment is not just do this once and forget about it. Sampling is the key concept in data collection. In general, you should gather the least amount of data that will give you the most information. In other words, some assessment methods may require input from all sources, other may only require strategically selected samples. Whenever possible, use or modify existing data collection opportunities to reduce the burden of data collection. For example, your university might already be collecting information you need. You will want to do a project cost analysis (i.e., in terms of materials and time) in conjunction with data collection and, in reality, this may impact how much data you can feasibly collect.

Figure 1. List of Assessment Methods Mapped to Objectives

A = knowledge of math, science and engineering
B = Design and conduct experiments; Analyze and interpret data
C = Design a system, process, or component
D = Multidisciplinary teams
E = Identify, formulate, and solve engineering problems
F = Ethics
G = Communicate effectively
H = Broad education to see societal impact
I = Lifelong learning
J = Knowledge of contemporary issues
K = Use modern tools
L = Working knowledge of chemistry
M = Working knowledge of ChE principles
N =
O =

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Senior Design Reports															
Senior Design Orals															
Unit Ops Lab Reports															
Clinic Reports															
Clinic Presentations															
FE Exam															
Portfolios															
E-portfolios															
Alumni Surveys															
Employer/Recruit Surveys															
Exit Interviews															
Peer Reviews															

Figure 2. List of Practices Mapped to Educational Objectives

A = knowledge of math, science and engineering
B = Design and conduct experiments; Analyze and interpret data
C = Design a system, process, or component
D = Multidisciplinary teams
E = Identify, formulate, and solve engineering problems
F = Ethics
G = Communicate effectively
H = Broad education to see societal impact
I = Lifelong learning
J = Knowledge of contemporary issues
K = Use modern tools
L = Working knowledge of chemistry
M = Working knowledge of ChE principles
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O =

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
ChE Courses															
Senior Design															
Unit Ops Lab															
Internships															
Oral Presentations															
General Eds															
Chemistry															
AIChE, SWE, etc.															

6) How do we keep track of things?

First, set up a data warehouse. You might want to include the following electronic folders for each program: self-study, syllabi, curriculum vita, tables, policies, references, (assessment) tools, data, and reports. Second, set up a data storage system for paper copies. Third, develop a timeline for the fall, spring and summer semesters with suggestions of what should occur early, in the middle or at the end of each semester. Obviously, assessment activities should be distributed in such a way that allows for moderate activity throughout each semester instead of periods with too much or too little collection. Finally, make each faculty member responsible for at least one assessment activity. This way, all instruments will be utilized without any one faculty member being overburdened. Each coordinator should maintain a set of written responsibilities as a reference to facilitate administering tools.

7) How do we plan improvements?

We recommend having a retreat during the summer each year that we called "the assessment marathon". Over two days, we discussed all aspects of our program including the data from each tool, in turn. We identified strengths and areas for improvement and made decisions affecting our curriculum and policies. These discussions were wonderfully productive and we left with a better feel for the program as a whole.

8.) Why won't anyone provide specific answers instead of some general advice?

Outcomes assessment is a highly personal activity. The whole point of moving away from bean counting and into outcomes was to enable programs to set their own goals, defend their importance, and prove that they are being achieved. Even the reviewer of an early draft of this paper asked "What should we collect - finals exams but not homeworks?, materials from every student or every tenth student?" There are no single answers to these questions. A program that graduates 15 students per year will keep different information than one who graduate 100 or more. If final exams are one of five assessment instruments you are using to demonstrate that you have achieved an objective, you may not need homeworks as well. You own the process and MUST make your own decisions.

III. Summary

The process of preparing for accreditation under Engineering Criteria 2000 is long and filled with challenges. Departments must begin to analyze their program goals early and recognize the size of the task that they face. Through progressive discussions and a systematic approach to planning, the task can be accomplished. Key points to remember include: identify your goals first, involve students and other constituents, minimize the data that you are required to collect and analyze, have multiple indicators for each objective (ideally involving multiple sources), and get started yesterday!

IV. Bibliographic Information

1. ABET Engineering Criteria 2000.

2. Felder, R, *Chemical Engineering Education*, 32 (2), 126 (1998).

3. Shaewitz, J., *Chemical Engineering Education*, 32 (2), 128 (1998).

V. Biographic Information

James Newell is an Associate Professor of Chemical Engineering at Rowan University. He serves as a Director of the Chemical Engineering Division of ASEE and has received the Dow Outstanding New Faculty Award. His areas of interest include high-performance polymers, integrating communications across the curriculum and undergraduate research.

Heidi Newell is currently the assessment/accreditation consultant for the College of Engineering at Rowan University. She previously served as the assessment consultant for the University of North Dakota. She hold a Ph.D. in Educational Leadership from the University of North Dakota, a M,S, in Industrial and Organizational Psychology from Clemson, and a B. A. in Sociology from Bloomsburg University.

Tom Owens has been the Chairman of the Chemical Engineering Department at the University of North Dakota since 1975 (with two brief interruptions to serve as acting Dean.). He holds a Ph. D. from Iowa State and is actively involved in self-paced learning, distance learning, and technical communications.

Rashid Hasan is a Professor of Chemical Engineering at the University of North Dakota, where he has been since 1979. Originally from Bangladesh, he holds a Ph.D. in Chemical Engineering from the University of Waterloo and his research focuses on multiphase flow modeling n weel-bores.

John Erjavec is as Associate Professor of Chemical Engineering at the University of North Dakota. He holds a Ph.D. from Princeton University and specializes in experimental design and statistical analysis of experimental data. He is actively involved with the Energy and Environmental Research Center.

Steven P. K. Sternberg is an Assistant Professor of Chemical Engineering at the University of North Dakota. His Ph. D. is from Purdue and his research focuses on flow through porous media and the use of native plant to remove metal contaminants from water. He is actively involved with novel teaching techniques and undergraduate research.