Learning Outcomes Assessment – Setting and Measuring Goals

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SUMMARY

ABET is the accrediting agency for most surveying/geomatics programs in the US. Since 2000, ABET has required that accredited programs demonstrate, among other criteria, both educational objectives and learning outcomes. Educational objectives reflect the potential of students some years after graduation while learning outcomes demonstrate student knowledge and abilities at the time of graduation. Learning outcomes must have characteristics defined by ABET and must be systematically measured, evaluated, and used for program improvement. Although learning outcomes can be broad, demonstration of outcomes requires specific measures such as student examination questions and student projects. The experiences of the New Mexico State University Surveying Engineering program are given as one approach to demonstrating student learning outcomes.

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1. INTRODUCTION

ABET is the recognized accreditation agency for applied science, engineering, technology and computing programs in the United States. In 2000 ABET changed the way programs were accredited going from a prescriptive format where program curriculum was rigidly set to a more flexible system that allows programs to identify their goals and then prove that they are achieving those goals. While ABET does accredit graduate programs, the focus is on undergraduate college and university programs.

To achieve accreditation, each program must request an accreditation visit. Prior to the visit, the program must prepare a self-study document detailing the qualifications of the students, faculty, facilities and program goals. This document is read by the visiting program evaluators who base their observations on material covered within the self-study.

Two sets of goals are required under the ABET 2000 initiative. The first set, educational objectives, define the expected career of program graduates. An example of an educational objective for most surveying/geomatics programs in the US is professional licensure of graduates as surveyors. A program can set a goal of having a percentage of graduates become professionally licensed within 5 years of graduation but must then track those graduates and document the number of graduates who become licensed. Another example of an educational objective would be to have a percentage of students who will be accepted to a graduate program.

The second set of goals are learning outcomes. Learning outcomes differ from educational objectives in that learning outcomes must be demonstrated by the time a student graduates or shortly thereafter.

ABET requires that both sets of goals be constantly self-evaluated and the results of self-evaluation be used to constantly improve the program.

2. LEARNING OUTCOMES

ABET has defined the characteristics of learning outcomes (known as ABET a-k) as follows:

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

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multi-disciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Some programs use the ABET definitions directly. ABET encourages programs to develop their own set of learning outcomes relate those outcomes to ABET a-k. The learning outcomes should directly relate to the educational objectives and both should conform to the college or university mission.

3. OUTCOMES DEVELOPMENT

New Mexico State University Surveying Engineering has 8 program learning outcomes. These were developed prior to ABET 2000 and have remained little changed since they were formulated. The learning outcomes are reviewed and endorsed on a regular basis (every 1 to 2 years) by an advisory committee consisting of professional surveyors who are graduates of our program or who hire graduates of our program. We are currently undergoing a long-term learning outcomes review that will probably see major changes made to the learning outcomes.

The NMSU Surveying Engineering learning outcomes states that graduates of the program will:

- acquire a sound and fundamental understanding of the scientific, mathematical, and engineering principles underlying technology;
- acquire a breadth and depth of education to understand the legal, political, and social context of surveying activities;

- develop the ability to appropriately collect, analyze, interpret, and apply survey and survey-related data;
- develop the ability to recognize, analyze, and solve survey and survey-related problems;
- acquire the verbal and written skills necessary to contribute productively to society;
- acquire an understanding of responsibilities and ethics of surveying professionals;
- develop the ability to work on multidisciplinary teams; and
- recognize the need for and develop the ability to engage in life-long study and learning.

Many of the NMSU learning outcomes relate to more than one of the ABET a-k outcomes. Programs can have learning outcomes that exceed the ABET a-k, but must be able to demonstrate that their outcomes include ABET a-k outcomes.

As can be noted from reviewing the NMSU learning outcomes, the language is general. The problem then becomes formulating a set of metrics that can conclusively measure each outcome.

4. OUTCOME METRICS

It is virtually impossible to measure every instance during a student's surveying education where he or she is achieving a given outcome, therefore selected instances of each outcome are selected and measured. ABET encourages the use of direct measurement of outcomes, for example by examination question or student project, as opposed to indirect measures such as student interviews or surveys.

For example, NMSU learning Outcome 3 states that graduates will "develop the ability to appropriately collect, analyze, interpret, and apply survey and survey-related data." Three direct measures were formulated to evaluate the outcome:

Measure 1: 80% of SUR 222 (Plane Surveying) students will receive a grade of "B" or better on their contour map project.

Measure 2: 80% of SUR 451 (Advanced Survey Measurements, Analysis and Adjustment) students will receive a grade of "B" or better on their network analysis project.

Measure 3: 80% of SUR 292 (Public Lands Survey System) students will receive a grade of "B" or better on their subdivision of section project.

In each of the three measures, student projects were collected and graded. While grading is primarily on the technical competency of the project, issues such as presentation, legibility and timeliness also enter into student grading.

For NMSU Survey Engineering Outcome 4, the ability to recognize, analyze, and solve survey problems, is comparable to ABET outcomes c and e. The measures are:

Measure 1: 80% of SUR 292 (Public Lands Survey System) students will correctly answer a question about obliterated survey corners on the midterm exam.

Measure 2: 80% of SUR 452 (Land Development Design) students will received a grade of 80% or better on their final subdivision project.

Measure 3: 80% of SUR 461 (Satellite Geodesy) students will correctly differentiate between code and carrier phase GPS on a question on their final exam.

In this case, two of the measures are specific examination questions that must be compiled separately by the instructor to measure the outcome.

Not all outcomes are so easily measureable. NMSU Outcome 8, life-long study and learning, relates to ABET outcomes l and j. No classroom project or examination seemed sufficient to measure this outcome. Instead, two more indirect measures are being used:

Measure 1: 50% or more of all Surveying Engineering graduating seniors will have attended at least one state or national surveying conference.

Measure 2: 50% or more of all Surveying Engineering graduating seniors will have belonged to at least one state or national surveying association.

In these measures, we keep track of students who have attended conferences (conference attendance is normally through the NMSU Survey Student Chapter and not difficult to track) and through records from the New Mexico Professional Surveyors association and the American Congress on Surveying and Mapping. Both of these organizations are great in providing us with needed data.

5. EVALUATING OUTCOME METRICS

When outcomes measures are achieved, there is no stress to take immediate action to improve results. The measures should still be evaluated to make sure that they are objective and valid. If the measure is consistently being achieved, additional measures should be included to validate achievement of the outcome.

However, when the measures are not achieved, consensus on action to improve the measures must be taken. By using the learning outcomes assessment method, programs should theoretically continue to improve. If a measure is consistently met, the measure should still be examined periodically to determine whether it is still relevant and whether the goal is too lenient. Use of the outcomes measure to formulate a plan of action is also known as “closing the loop” (see diagram 1).

The best measures are those where student project and exam grading are reviewed by those outside program faculty.

Each NMSU Surveying Engineering learning outcome measure is assigned to a specific faculty member, usually the instructor of the course where the measure is being implemented.

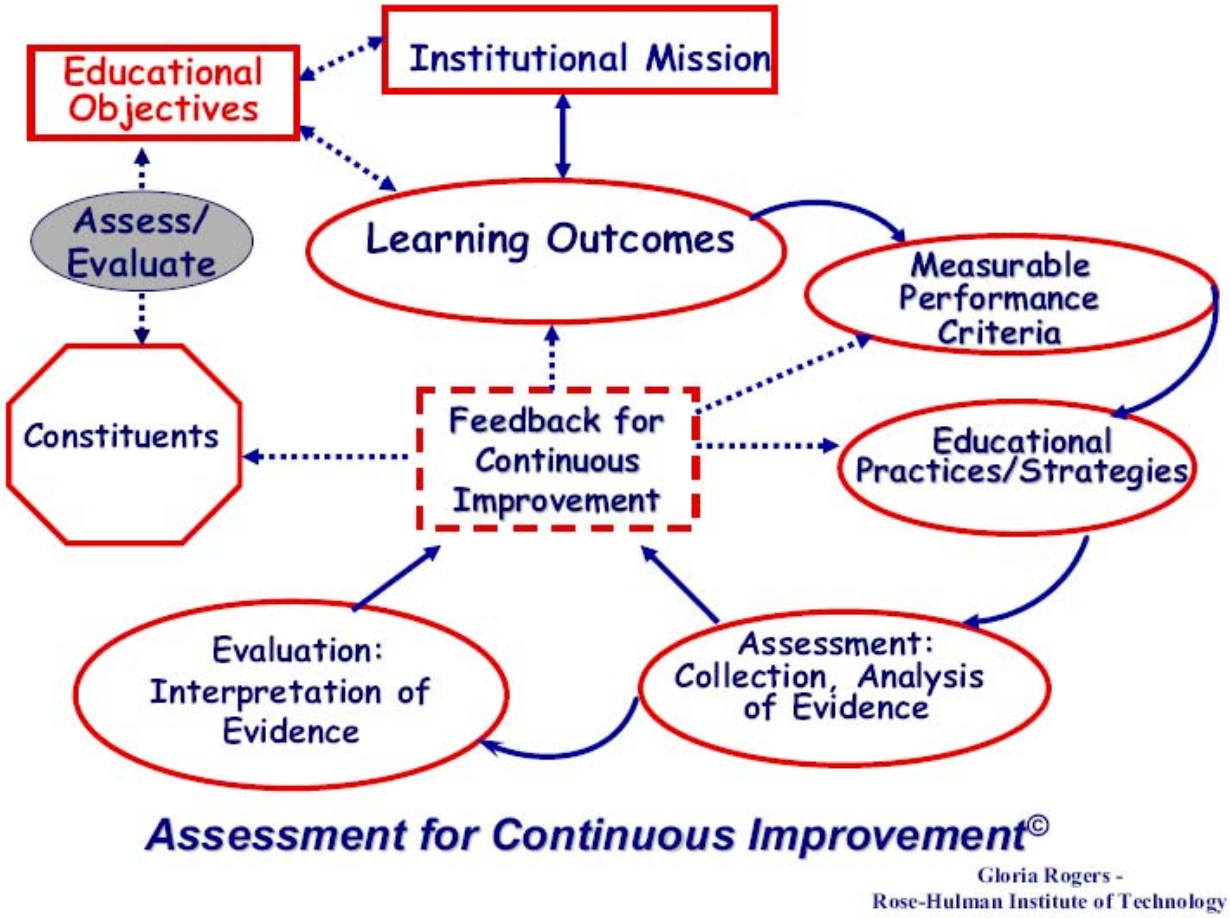

Diagram 1 – Continuous Improvement Loop

6. OBSERVATIONS AND CONCLUSIONS

Learning outcomes are not new to the NMSU Surveying Engineering program. Much of the measures were being done on an informal, undocumented basis prior to ABET 2000. The challenge has been to set up a system to formally measure, evaluate and document the process. Setting up the formal process has gained some insights.

Not all the learning outcomes relate to survey technical issues. Therefore, courses outside of surveying, such as English and speech classes, are taught in other departments. The Surveying Engineering program must make sure that written projects and oral presentations are required in Surveying Engineering courses to provide the measures.

The measures most consistently met are those implemented in upper level surveying courses. This appears to be the case because students who will fail or drop out of the program are normally gone by the time these courses would come up in their schedule. I would conjecture that eventually all of the measures will relate to upper level students.

Survey licensure examinations are standardized and are given by the National Council of Examiners for Engineers and Surveyors (NCEES). Recently NCEES has begun providing statistics comparing individual program results to national results. Some surveying/geomatics programs in the US are apparently using these measures to validate their learning outcomes. The NMSU Surveying Engineering program is investigating using these results. The advantage is the exams are graded and the results are tabulated anonymously so there is no worry of bias in the results. Since the exams are composed of several topic areas, each topic area is individually evaluated by NCEES making the use of these flexible. The disadvantage of using the NCEES exam results would be that program would need to require that all graduating students take the exam as a condition of graduation.

REFERENCES

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BIOGRAPHICAL NOTES

Steven Frank is an Associate Professor in the Engineering Technology and Surveying Engineering Department at New Mexico State University. He received his Bachelors and Master degrees from California State University, Fresno, and his PhD from the University of Maine. He is a licensed professional surveyor. He is a past president of the New Mexico Professional Surveyors and the American Association for Geodetic Surveyors. He is the editor of Surveying and Land Information Science.

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