

## A Procedure to Assess Student Outcomes in the Penn State Surveying Programs

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### ABSTRACT

In 2009 the faculty of the Penn State Surveying Engineering and Surveying Engineering Technology programs developed a new procedure to assess the degree that student outcomes are met in preparation for periodic ABET reviews. The procedure was used in the successful re-accreditation of both programs following 2012 ABET general reviews. This paper reviews the development of the procedure, which is based on an ABET workshop manual on outcome assessment (Rogers, 2008). The plan of periodic outcome assessment over the six years between general reviews is outlined. Student outcomes assessed and performance criteria to indicate the meeting of outcomes are listed. The selection of particular courses and student course work on which to base periodic assessment is described. The assessment procedure is outlined. The evaluation of the periodic outcome assessment combining different course work into a single assessment of the degree to which an outcome is met is described. The various components of evaluation, combining of scores from different course work, commentary by faculty teaching the courses, curriculum committee review, industrial advisory committee review, and finally the determination of remedial action, where necessary, to improve results of future year's assessments is described. The periodic updating of the assessment accounting the effect of changes to courses is described. To illustrate the procedure the 2012 assessment of a particular student outcome in the Surveying Engineering program is presented.

### INTRODUCTION

Following the last general review of the SUR E program in October 2005 Program faculty developed a new outcome assessment for the interim report in 2009. The assessment was continued in preparation for successful general reviews of both the SUR E and SURET programs in 2012.

The Program assesses the extent to which EAC student outcomes “a” to “k” are met using a procedure adapted from material in an ABET manual on assessing outcomes (Rogers, 2008) prepared by and used in conjunction with a workshop presented by Gloria Rogers, Ph.D., Associate Executive Director, Professional Services, ABET. One of us (Parks) participated in this workshop presented Spring, 2008 in Baltimore, MD.

The assessment of the degree to which the SUR E Program meets student outcomes is described here; the assessment for the SUR ET program is essentially the same, only the specific outcomes are different.

### PERIODIC ASSESSMENT PLAN

ABET wants to see that the degree to which outcomes are met is continuously assessed. In response to this continuous assessment requirement program faculty assess the extent to which each of the 11 EAC student outcomes “a” to “k” are met every three years or twice during the period between consecutive ABET general reviews. This pattern results in three or four outcomes assessed each year. The schedule of assessment follows.

Outcome	Assessment year					
	1	2	3	4	5	6
a	x			x		
b		x			x	
c			x			x
d	x			x		
e		x			x	
f			x			x
g	x			x		
h		x			x	
I			x			x
j	x			x		
k		x			x	
No. assessed per year	4	4	3	4	4	3

#### OUTCOMES AND PERFORMANCE CRITERIA

For the 2005 general review of the SUR E program, the program used a list of 24 program outcomes. Since ABET EAC requires that ABET outcomes “a” to “k” and all program outcomes be assessed, the programs adopted student outcomes of EAC for the SUR E program and student outcomes of ETAC for the SUR ET Program.

The ABET outcome assessment workshop manual defines outcomes as “statements that describe what students are expected to know and able to do by the time of graduation.” Once outcomes are determined the workshop manual calls for statements of performance criteria, “...those specific actions that students do that indicate that they have satisfactorily learned the subject content described by the outcome.” The terms outcome and performance criteria are referred to in each outcome assessment.

Outcomes used in the 2012 outcome assessment for the SUR E program are as follows. Outcomes and performance criteria are listed in Appendix A.

Outcome	Outcome statement Performance Criteria
a	Engineering programs must demonstrate that their students attain an ability to apply knowledge of mathematics, science, and engineering.
b	Engineering programs must demonstrate that their students attain an ability to design and conduct experiments, as well as to analyze and interpret data.
c	Engineering programs must demonstrate that their students attain 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 Engineering programs must demonstrate that their students attain an ability to function on multi-disciplinary teams.
  - e Engineering programs must demonstrate that their students attain an ability to identify, formulate, and solve engineering problems.
  - f Engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility.
  - g Engineering programs must demonstrate that their students attain an ability to communicate effectively.
  - h Engineering programs must demonstrate that their students attain the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
  - i Engineering programs must demonstrate that their students attain a recognition of the need for, and an ability to engage in life-long learning.
  - j Engineering programs must demonstrate that their students attain a knowledge of contemporary issues.
  - k Engineering programs must demonstrate that their students attain an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
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## COURSES AND STUDENT COURSE WORK USED TO ASSESS OUTCOMES

The ABET outcome assessment workshop manual defines the following terms related to outcome assessment.

Strategies for assessment of a particular outcome is “...the range of required courses or other organized program activities that can be used to assess the attainment of an outcome.”

Source of assessment is “...the particular courses or activities used for the current assessment.” These terms are referred to in each outcome assessment.

Assessment method is “...the specific activity (e.g. exam question, project report or student survey question) on which student performance can be measured.”

Grading criteria are “...the specific ways student performance is measured.”

For the assessment of each outcome there are a number of strategies by which the outcome can be assessed. For each outcome assessment a subset of strategies are chosen. Then specific assessment methods for each strategy are selected and grading criteria developed. As an example, strategies, sources of assessment, assessment methods and grading criteria for the 2012 assessment of SUR E outcome “a” are as follows.

1. First EAC outcome “a” is stated: “Engineering programs must demonstrate that their students attain an ability to apply knowledge of mathematics, science, and engineering.”
2. Then strategies (Courses in which learning outcome is addressed) are listed:  
Required SUR E courses: SUR 111, SUR 241, SUR 351, SUR 381\*, SUR 455\*.  
Other strategies: end of course student surveys, end of program student exit survey.  
\* Courses required beginning Fall 2011.
3. Then the sources of the 2012 assessment are listed: Objective assessment methods chosen use material generated in SUR 111 (Fa 2008) and SUR 241 (Fa 2008). These methods provide material most relevant to the outcome. Subjective assessment methods chosen use material generated by end of course student surveys and the end of program student exit survey.
4. Performance criteria (the specific action(s) that students do that indicate that they have satisfactorily learned the subject content described by the outcome) are stated:  
Demonstrate the ability to apply understanding of typical measurement types used in plane surveying.
5. There are a number of assessment methods for the assessment of a particular outcome. For the 2012 assessment of EAC outcome a there are three objective methods and three subjective methods. Each method is stated then grading criteria are listed followed by results by grading criteria and a reference to attached examples of student work. The following illustrates the listings for assessment method 1.

Assessment method 1: SUR 111 (Fa 2008): quiz on differential leveling measurement including standard note-form, survey closure, and level loop adjustment.

#### Grading Criteria

1. Passing score is 40 or higher out of 50. Each student is given 3 attempts to pass.

#### Results by grading criterion.

1. Sample 17, Score: pass is 40/50. Pass: 16, Fail 1. Pass rate: 16/17 (94.1%)

Examples of Student work: 3 student quizzes (2 pass, 1 fail).

#### THE OUTCOME ASSESSMENT PROCEDURE

Assessments of the degree to which the Program has attained EAC student outcomes “a” to “k” are made by outcome. The format of the assessment of an outcome is as follows.

1. Strategies are listed.
2. Sources of the particular assessment are listed.
3. Performance criteria are listed.
4. Assessment methods are listed.

5. By method, grading criteria and results are listed.
6. Performance is evaluated as follows:
  - a. Mean (over all or a sample of students) grade of performance typically is reported normalized, as a percentage.
  - b. Evaluation of performance on criteria is by the following rubric designed to reflect a working surveyor's ability:
    - $\geq 90\%$  = Expert
    - 80 – 89% = Very competent
    - 70 – 79% = Competent
    - $< 70\%$  = Less than competent
  - c. Where the score for any grading criterion of any assessment method is less than 70% the faculty member delivering the course that is the strategy by which the outcome is assessed, comments on his interpretation of this result and suggests actions to improve the score when the course is used in the future to assess the outcome.
  - d. The Faculty Curriculum Committee reviews the assessment and any instructor's comments and recommends any changes to the course or assessment plan.
  - e. The Surveying Industrial Advisory Committee reviews the assessment, any instructor comments and Curriculum Committee recommendations and either endorses these or makes its own recommendations.
  - f. The faculty member delivering the course reviews the above and declares his intended actions with respect to the recommendations.

#### EVALUATION OF THE DEGREE TO WHICH OUTCOMES ARE MET

Once an outcome is assessed as described above, the degree to which the outcome is met by the program is evaluated and interpreted using a rubric applied to the mean of scores on student performance on individual performance criteria in student activities used to assess that outcome as follows.

#### Rubric for Assessment of Achievement of SUR E student outcomes

Score	Level of achievement	Action
$\geq 90\%$	Outstanding	No change necessary. Continue to assess regularly.
$< 90\% \geq 80\%$	Very good	No change necessary, however, review courses and noncourse related activities to identify areas of instruction or academic experiences that support this outcome. Look for areas that need improvement. Implement change as deemed appropriate, and continue to assess regularly.
$< 80\% \geq 70\%$	Acceptable	Review all courses and noncourse related activities that relate directly to this educational outcome. As deemed appropriate, modify or create new methods to deliver instruction or academic experiences to

improve achievement of the outcome. Implement regulated change as deemed appropriate and continue to assess regularly.

< 70%

Unacceptable

Review all courses and noncourse related activities that relate directly to this educational outcome. Modify or create new methods to deliver instruction or academic experiences to improve achievement of the outcome. Implement broad change as necessary, and continue to assess regularly.

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#### PERIODIC UPDATE OF ASSESSMENT

As noted above the degree to which a student outcome is met is assessed using student performance material twice during an assessment cycle. The above process documents the procedure of one assessment. Material for the second assessment of the cycle is simply added to the first assessment and the evaluation extended accordingly.

#### AN EXAMPLE ASSESSMENT

An example of the multi-year assessment of one student outcome (outcome “f”) is included as Appendix B.

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APPENDIX A. Outcomes and performance criteria used in the 2012 outcome assessment for the SUR E program.

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Outcome	Outcome statement Performance Criteria
a	Engineering programs must demonstrate that their students attain an ability to apply knowledge of mathematics, science, and engineering. <u>Performance Criterion:</u> Demonstrate the ability to apply understanding of typical measurement types used in plane surveying.
b	Engineering programs must demonstrate that their students attain an ability to design and conduct experiments, as well as to analyze and interpret data. <u>Performance Criterion:</u> Demonstrate the ability to develop, test, and improve a technique to solve a problem.
c	Engineering programs must demonstrate that their students attain 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. <u>Performance Criteria:</u> <ol style="list-style-type: none"><li>1. Demonstrate the ability to collect data appropriate to solving a problem.</li><li>2. Demonstrate the ability to analyze data to identify conflicts in evidence dealing with a problem.</li><li>3. Demonstrate the ability to resolve conflicts in evidence to solve a problem.</li></ol>
d	Engineering programs must demonstrate that their students attain an ability to function on multi-disciplinary teams. <u>Performance Criteria:</u> Demonstrate an ability to perform the different aspects of a typical field survey, including: <ol style="list-style-type: none"><li>1. participating in pre-survey planning and preparation,</li><li>2. participating in a crew survey,</li><li>3. participating in the analysis of survey information and report writing.</li></ol>
e	Engineering programs must demonstrate that their students attain an ability to identify, formulate, and solve engineering problems. <u>Performance Criteria:</u> <ol style="list-style-type: none"><li>1. Demonstrate the ability to identify an appropriate set of surveying procedures to collect and analyze information to solve a surveying problem.</li><li>2. Demonstrate the ability to properly analyze data and communicate the results of analysis.</li></ol>
f	Engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility.

Performance Criterion: Demonstrate an understanding of the professional responsibility of the land surveyor to the client, the public and the profession.

- g Engineering programs must demonstrate that their students attain an ability to communicate effectively.  
Performance Criterion: Demonstrate an ability to prepare a report in a format appropriate to the material to be presented and the audience.
- h Engineering programs must demonstrate that their students attain the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.  
Performance Criteria:
  1. Demonstrate an understanding of the attributes of land surveying that emphasize an obligation to society with its diversity of individuals.
  2. Demonstrate an understanding of the attributes of land surveying that make it a profession.
  3. Demonstrate an understanding of the land surveyor's obligation to society.
  4. Demonstrate an understanding of the place of land surveying in humanity's need for secure property ownership.
- i Engineering programs must demonstrate that their students attain a recognition of the need for, and an ability to engage in life-long learning.  
Performance Criteria:
  1. Demonstrate an ability to research a topic related to surveying and present the research in a student/faculty seminar.
  2. Take advantage of membership opportunities in the Penn State Student Surveying Society (PSSS) and in the Pennsylvania Society of Land Surveyors (PSLS).
  3. Take advantage of opportunity to participate in a leadership position in the PSLS continuing education program.
- j Engineering programs must demonstrate that their students attain a knowledge of contemporary issues.  
Performance Criteria:
  1. Demonstrate an ability to research a topic related to surveying and present the research in a student/faculty seminar.
  2. Take advantage of membership opportunities in the Penn State Student Surveying Society (PSSS) and in the Pennsylvania Society of Land Surveyors (PSLS).
  3. Take advantage of opportunity to participate in a leadership position in the PSLS continuing education program.
- k Engineering programs must demonstrate that their students attain an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Performance Criterion: Demonstrate an understanding of typical measurement types used in plane surveying.

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APPENDIX B. Assessment of student outcome f for 2012 ABET general review of the Penn State SUR E Program.

2012 EACO f. Engineering programs must demonstrate that their students attain an understanding of professional and ethical responsibility.

Strategies (Courses in which learning outcome is addressed):

Required SUR E courses: SUR 272, SUR 372W, SUR 471.

Other strategies: end of course student survey, end of program student exit survey.

Source of assessment 2012: Objective assessment methods chosen use material generated in SUR 272 (Fa 2008), SUR 471 (Fa 2008), SUR 272 (Fa 2010) and SUR 471 (Fa 2010). These methods provide material particularly relevant to the outcome. Subjective assessment methods chosen use material generated by an end of course student survey and the end of program student exit survey.

Performance Criteria:

1. Demonstrate an understanding of the professional responsibility of the land surveyor to the client, the public and the profession.

Assessment method 1: SUR 272 (Fa 2008). Research exercise 1: characteristics of land surveying (primary focus: professional and ethical responsibility).

Grading Criteria:

Prepare a report of research.

1. Format to specifications.
2. Procedure (of research and oral report).
3. Results.
4. Definition of land surveying (considering results of research).

Results by grading criterion.

1. Sample 7 of 8, Score (max 20): range 14 – 20, mean 17.1 (85.7%), std. dev. 2.7.
  2. Sample 7 of 8, Score (max 20): range 14 –20, mean 17.4 (87.1%), std. dev. 2.5.
  3. Sample 7 of 8, Score (max 30): range 21 – 30, mean 26.0 (86.6%), std. dev. 3.0.
  4. Sample 7 of 8, Score (max 30): range 23 – 28, mean 26.0 (86.6%), st.d dev. 2.0.
- Combined

Sample 7 of 8, Score (max 100): range 77 – 98, mean 86.5 (86.5%), std. dev. 7.3.

Examples of Student work: 3 student reports (one lower grade, one middle grade, one higher grade).

Assessment method 2: SUR 471 (Fa 2008): exam dealing with professional and ethical responsibility of land surveyors

Grading criteria:

1. A set of 3 questions testing the ability to correctly apply Pennsylvania registration laws and code of ethics to a hypothetical survey situation.

2. A set of 6 questions testing the ability to correctly apply laws of presentation of evidence to a hypothetical survey situation.

Results by grading criterion.

1. Sample 7 of 13, Score: max 33, range 21 – 33, mean 27.5 (83.5%), std. dev. 3.7.

2. Sample 7 of 13, Score: max 67, range 51 – 62, mean 58.7 (88.9%), st. dev. 3.6.

Combined

Sample 7 of 13, Score: max 100, range 79 – 96, mean 87.2 (87.2%), std. dev. 5.7.

Examples of Student work: 3 student exams (one lower grade, one middle grade, one higher grade).

Assessment method 3: Questions on end of SUR 272 student survey (Fa 2008).

1. As a result of completing SUR 272 rate your understanding of the professional responsibility of the land surveyor to society.

Results by question.

1. Sample: 8, Score (1 to 7): range: 3 – 7, mean: 5.6 (80.3%), std. dev. 1.2.

Assessment method 4: Question on end of program student exit survey (Sp 2008).

Question:

1. As a result of completing the surveying curriculum rate your understanding of the professional responsibility of the land surveyor to society.

Results:

1. Sample: 9, Rating: 1 – 5(highest), score: range: 3 – 5, Mean score: 4.38 (87.5%)

Assessment method 5: SUR 272 (Fa 2010). Research exercise 1: characteristics of land surveying (primary focus: professional and ethical responsibility).

Grading Criteria:

Prepare a report of research.

1. Format to specifications.

2. Procedure (of research and oral report).

3. Results.

4. Definition of land surveying (considering results of research).

Results by grading criterion.

1. Sample 15, Score (max 20): range 15 – 20, mean 18.9 (84.57%), std. dev. 2.1.

2. Sample 15, Score (max 30): range 20 – 30, mean 25.3 (84.3%), std. dev. 5.2.

3. Sample 15, Score (max 30): range 25 – 30, mean 29.7 (99.0%), std. dev. 1.2.

4. Sample 15, Score (max 30): range 25 – 30, mean 29.7 (99.0%), std. dev. 1.2.

Combined

Sample 15, Score (max 110): range 95 – 110, mean 103.5 (94.1%), st. dev. 5.3.

Examples of Student work: Not collected; the assignment is the same as for assessment method 1; See assessment method 1 for examples.

Assessment method 6: SUR 471( Fa 2010): exam dealing with professional and ethical responsibility of land surveyors

Grading criteria:

1. A set of 3 questions testing the ability to correctly apply Pennsylvania registration laws and code of ethics to a hypothetical survey situation.

2. A set of 6 questions testing the ability to correctly apply laws of presentation of evidence to a hypothetical survey situation.

Results by grading criterion.

1. Sample 11, statistics not provided separately.

2. Sample 11, statistics not provided separately.

Combined

Sample 11, Score: max 100, range 67 – 94, mean 80.2 (80.2%), std. dev. 7.1.

Examples of Student work: Not collected; the assignment is the same as for assessment method 2; See assessment method 2 for examples.

Evaluation/action

NOTE: Evaluation of performance on criteria: > 90% = expert, 80 – 89% = very competent, 70 – 79% = competent, < 70% = less than competent.

- 1) Results of objective assessment methods 1, 2, 5 and 6 suggest that students completing courses used to assess this outcome have attained very competent to expert (scores ranged from 80 to 94%; weighted mean combined score 87.7%) knowledge as defined by the criterion.
- 2) Results of subjective assessment method 3 suggest that at the end of one of the courses used to assess this outcome, students are confident of their knowledge as defined by the criterion, assessing their knowledge as very competent (mean score 80.3%).
- 3) Results of subjective assessment method 4 suggest that as a result of participating in the surveying curriculum, students soon to complete the program are confident of their knowledge as defined by the criteria, assessing their knowledge very competent (mean score 87.5%).
- 4) In its 2009 review of assessment of this outcome using SUR 272, the Faculty Curriculum Committee felt that results did not warrant any changes to the course. They suggested that questions on student surveys could be revised to focus more on the performance criteria for this outcome. As a result of this suggestion the performance criterion has been changed to more accurately reflect the outcome. The questions on the 2009 student surveys in this course focus on this criterion.
- 5) In 2011 the Faculty Curriculum Committee reviewed results of 2009 assessment; the Committee felt that results did not warrant any changes to the course. The Committee felt that the current assessment plan is adequate. In 2012 the assessment was augmented with additional material. The Committee reviewed the augmented assessment by e-mail poll; the Committee continued to feel that results did not warrant any changes to the course and that the current assessment plan is adequate.
- 6) In April 2012 the Industrial Advisory Committee reviewed results of the 2009 assessment and the Curriculum Committee's review. The Committee concurred with the Curriculum Committee's review. The assessment was subsequently augmented with additional material. The Committee reviewed the completed assessment by e-mail poll; a majority of Committee members responded to the poll; all responding concurred with the Curriculum Committee's review.
- 7) The faculty members delivering these courses will review performance criteria and assessment methods prior to the next delivery of the courses and make changes as appropriate.

## REFERENCES

Rogers, Gloria. 2008. Faculty workshop on assessing program outcomes. A spiral bound manual for use in an ABET workshop. ABET, Inc., Baltimore, MD. 104 p.

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