Effective, Efficient, Direct Assessment of Programmatic Outcomes

Matthew A. Dettman
Western Kentucky University

Western Kentucky University is in the late stages of completing it's first ever EAC of ABET accreditation process. The self study reports for civil, electrical, and mechanical engineering were submitted in July of 2004, the site visit took place in November of 2004, and the final recommendations of the evaluators will be presented to the ABET board in July of 2005. While a discussion of that visit is not allowed at this time, a mock visit was performed by a former ABET evaluator in the summer of 2004 who found all 3 programs to be in very good shape with respect to meeting the necessary requirements for accreditation. In addition, the entire engineering faculty attended multiple training and working sessions run by Ron Miller and Barbara Olds, both of whom are well known and respected in the area of outcomes assessment, in the early stages of the development of the programmatic objectives and outcomes. This paper will present the method developed to utilize direct assessment of outcomes in an efficient manner in order to eliminate potential problems in the area that most institutions struggle with, which is Criterion 3.

The WKU CE faculty, with input from constituencies, developed the following programmatic outcomes for the Civil Engineering programs:

Outcome 1 (Physical Analysis) - Civil Engineering graduates will demonstrate the mathematical, experimental, and engineering science skills required in the civil engineering problem solving and design process.

Outcome 2 (Professional Analysis) - Civil Engineering students will demonstrate recognition of the non-technical issues important in the civil engineering design process, including recognition of the importance of society and contemporary issues in their professional practice, constructability, economics, availability, and aesthetics.

Outcome 3 (Synthesis) - Civil Engineering students will be able to synthesize physical and professional analyses in their designs.

Outcome 4 (Teamwork) - Civil Engineering students can work effectively in multi-disciplinary teams to identify, develop, and execute the solution to a problem.

Outcome 5 (Management) - Civil Engineering students can effectively participate in the management of a project.

Outcome 6 (Communication) - Civil Engineering students demonstrate effective communications skills.

Outcome 7 (Regional Relevancy) - Civil Engineering students are able to find employment, primarily regionally, with organizations that traditionally employ civil engineers.

Outcome 8 (Life Long Learning) - Civil Engineering students demonstrate development of habits associated with life long learning.

Outcome 9 (Professionalism / Ethics) - Civil Engineering students show common characteristics of professionalism and knowledge of ethical behavior.

Outcome 10 (Engineering Tools) - Civil Engineering students can effectively use state of the practice civil engineering technical tools.

With the outcomes developed, the task of developing an assessment process began with the workshops presented by Dr. Miller and Dr. Olds. During the workshops, they presented general methods for the collection and assessment of outcomes using both direct and indirect methods [1,2]. In addition, the document developed by the Rose Hulman Institute of Technology was also used during the process[3].

Armed with this wealth of information, the faculty ultimately had to determine the specifics of how to assess the outcomes considering some specific issues surrounding the WKU Civil Engineering program, including the following:

1. The CE faculty consists of only 4 people, therefore, the assessment workload cannot be burdensome,
2. The WKU Engineering programs are project based which the faculty must be evident in the outcomes assessment process,
3. The programs are going through their first EAC of ABET accreditation, therefore the opinion was that the Criterion 3 requirements must not only be met, but comfortably exceeded to avoid any possibility of a deficiency in this area.

Based on the necessary background information as well as considering some specific issues surrounding the CE program, the faculty decided to focus assessment on direct measures of student work utilizing student design projects as much as possible. It was very apparent based on attendance in the Olds/Miller workshops, as well as continual review of "Communications Link: ABET Quarterly News Source", that direct methods of assessment are the best way to determine what students know and are capable of doing, rather than through grades or surveys [4]. In addition, it has been shown that utilizing specific portions of classroom activities, such as student projects, are very effective at not only assessing the outcomes, but actually achieving the outcomes[5].

It was determined that the plan should focus on assessing a group of students, not assessing each student. The first draft of the assessment plan consisted of collecting and assessing a great deal of student work. Upon review of the draft, some feedback from Dr. Miller, and further research, the decision was made to collect a much smaller set of student work with the idea that a cross sectional profile is enough[6]. For example, if technical writing is being assessed and lab reports from 3 different courses are being collected, the question must be answered; "is different information being assessed in the different courses?". If all 3 reports are assessing the same thing, then 1 is enough. If a student can write effectively about a soil mechanics laboratory project, it is reasonable to expect that the same student can write effective about a fluid mechanics laboratory project. This decision also addressed the issue of developing an assessment process that would not be too burdensome for the small faculty.

The last piece of the assessment puzzle to come into place was possibly the most difficult. This piece was how to pick a piece of student work and assess it. To do this, the faculty developed a set of performance indicators for each outcome to quantify what it is that the student must know or be able to do in order to demonstrate that they have achieved the outcome. With the performance indicators determined, a rubric was then constructed that would appropriately determine if the student was achieving the outcome. Each rubric was designed such that the descriptors given for the desired score of 3 out of 4 represent a student who generally is proficient in the outcome being assessed. A great deal of effort was placed into the definition of "proficiency" in each of the outcomes[7] and based on a complete cycle of assessment, the faculty feel that the rubrics worked very well.

The following is a detailed look at the assessment plan and the rubrics for Outcome 1, which is essentially the engineering science and experimentation outcome.

Outcome One
Civil Engineering graduates will demonstrate the mathematical, experimental, and engineering science skills required in the civil engineering problem solving and design process.

Performance Criteria
The CE faculty have developed the following performance criteria for the math, experimentation, and engineering science skills for this outcome. Each student should be able to do the following:

Experimentation
1. Perform the experiment and/or collect the data in accordance with the applicable standard,
2. Perform the necessary calculations or data reduction to achieve the desired result,
3. apply the results to a practical situation

Engineering Science and Mathematics
1. Prepare the appropriate physical model of the problem
2. Apply and perform the correct mathematical analysis
3. Present the final result in the appropriate manner

Evaluation Methods:
1. Experimentation – CE faculty evaluations of selected student work in CE 411 Soil Mechanics Lab.
2. Engineering Science Analysis - CE faculty evaluations of selected student work in CE 316 Construction Equipment and Methods, CE 382 Structural Analysis, and CE 410 Soil Mechanics.
3. Additional Data – Scores on the FE exam, senior exit surveys, and a focus group of regional CE employers to evaluate selected student work.

Experimentation Scoring Rubric	Western Kentucky University CE Department

Group members: ______________ **Lab Session:** ______ **Experiment:** __________

Outcome	4 Exemplary	3 Proficient	2 Apprentice	1 Novice	Score
Experimentation: Data collection and engineering standards	Students conduct experiment with no errors, follow appropriate standards and/or procedures, data reduction correct, correct interpretation of results, and if applicable applies the results to a practical situation	Students conduct experiment with virtually no errors; standards and/or procedures generally followed; data reduction, interpretation of results, and application of results to practical situation (if applicable) generally correct	Students conduct experiment with some errors or multiple trials to obtain correct results; some errors in data reduction, results somewhat misinterpreted, application of results (if applicable) shows some significant errors.	Students conduct experiments with major conceptual and/or procedural errors; data reduction has major mistakes, no evidence of significant analysis and interpretation of results; fail to meet requirements of the experiment; does not apply the results to a practical situation	
Experimentation: Designing an experiment or experimental procedure	Students select and/or design all appropriate test(s) or process(es) to the situation at hand. They correctly apply the results to the intended outcome	Students generally select and/or design the appropriate test(s) or process (es) to the situation at hand. Results generally applied correctly to the intended outcome. Only minor errors noted	Students select or design some appropriate tests or processes, but some important data or result left out. Results obtained generally applied to intended outcome.	Students select or design some appropriate tests or processes, but significant important data or result left out. Results obtained incorrectly applied to intended outcome.	

Note: The descriptors given for the different levels are general targets for the achievement of the outcome. The evaluator should ultimately use his/her best judgment ultimately as to the appropriate level of achievement.

Comments:

Evaluator: ____________________ Date: __________

Engineering Science / Mathematics **Scoring Rubric**	Western Kentucky University CE Department

Student: ____________________ **Course:** __________ **Semester/Year:** ______________

Objective	4 Exemplary	3 Proficient	2 Apprentice	1 Novice	Score
Physical Model	Applies correct concepts to formulate a model with no errors affecting the problem solution.	Applies correct concepts to formulate a model with no conceptual and only one or two minor procedural errors.	Applies correct concepts to formulate a model; solution is conceptually correct but contains several procedural errors.	Applies incorrect concepts to formulate a model or solution contains conceptual or procedural errors affecting the problem solution.	
Mathematical Analysis	Applies correct mathematical concepts to formulate a model with no errors affecting the problem solution.	Applies correct mathematical concepts to formulate a model with no conceptual and only one or two minor procedural errors.	Applies correct mathematical concepts to formulate a model; solution is conceptually correct but contains several procedural errors.	Applies incorrect mathematical concepts to formulate a model or solution contains conceptual or procedural errors affecting the problem solution.	
Final Result	Final result is correct and presented in the most appropriate format	Final result is correct, presentation of answer generally appropriate	Final result and/ or presentation reflect noticeable errors	Final result is incorrect, answer presented inappropriately	
Overall problem solving techniques	Solves problem using logical step-by-step and efficient procedure and obtains correct solution.	Solves problem using logical step-by-step procedure and obtains correct solution.	Solves problem using logical step-by-step procedure but makes minor procedural errors resulting in incorrect solution.	Solves problem without logical step-by-step procedure and makes procedural errors resulting in incorrect solution.	

Note: The descriptors given for the different levels are general targets for the achievement of the outcome. The evaluator should ultimately use his/her best judgment ultimately as to the appropriate level of achievement.

Comments:

Evaluator: ______________________ Date: __________

As can be seen, a focus group of engineering practitioners was invited in to perform a direct assessment of select student work. The group included presidents of consulting firms, members of the state board of engineering licensure, chief engineers for the highway department, and others of a similar background and level of achievement. They used a simplified assessment tool which asked them to determine if the work was exceptional for a typical CE graduate, satisfactory, borderline, or unacceptable. This same group also assessed some final exams, homework assignments, lab reports, and a written report on engineering ethics and came to a similar conclusion in each case; that the students work was generally exceptional. All of this data was documented, presented in the ABET Self Study, and reviewed by the CE program evaluator during the site visit.

In addition to the direct assessment, a method of indirect method of assessment was also utilized which consisted of performing a senior survey to determine if the graduating seniors felt that they had achieved each of the programmatic outcomes. The expectation was that the students would respond positively that they had achieved the outcomes, however, the faculty felt it was important to gather the data to verify this as well as track any potential trends in student perception of achievement of outcome.

The assessment of the other outcomes was essentially the same. For each outcome, with the exception of Outcome 7 Regional Relevancy, direct assessment of student work was used as the primary source of determining whether or not the outcome was achieved. In many cases, the same piece of work was used to assess multiple outcomes to minimize the quantity of material collected. For example, the soil mechanics laboratory report was used to assess the students ability to design and conduct an experiment as well as their ability to write effectively. Over time, it is anticipated that even less student work will need to be collected as the faculty improve their efficacy in outcomes assessment and their ability to design projects and assignments that both meet the needs of the course in which the project or assignment was given as well as assessing programmatic outcomes.

In conclusion, the WKU Civil Engineering faculty feel that an effective, efficient, direct assessment of programmatic outcomes has been achieved. The evaluation of student work is the best way to demonstrate what students are able to do and what they have learned. By utilizing a small, carefully selected set of student projects or assignments, the faculty can minimize the amount of work collected as well as speed up the assessment process. If a very concentrated effort is put forth early in the process of developing an assessment plan to create assessable performance criteria for each outcome, to design rubrics that accurately capture what it means to be “proficient” in the desired outcome, and then to collect a minimal amount of student work that is a representative sample of the group of students being assessed, the achievement of Criterion 3 can be done with a sustainable amount of effort.

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MATTHEW A. DETTMAN
Mr. Dettman is the James D. Scott Professor of Civil Engineering. He is currently the civil engineering program coordinator at Western Kentucky University and his primary areas of interest are in Geotechnical Engineering and Construction Quality Control. He was named Civil Engineering Educator of the Year in the state of Kentucky in 2002, and currently serves on the Governors Council for Earthquake Risk Reduction.