ASEE's 123rd Annual • Conference & Exposition • New Orleans, LA • June 26-29, 2016

Paper ID #17083

Improving Engineering Learning Outcomes Assessment through Performance Indicators

Dr. Doanh Van, Union University

Doanh Van, PhD., PE, CEM is founding Chair of Union University Engineering Department. Currently, he is serving as professor of Engineering. Among the courses he teaches are thermal-fluids, energy conversion and solid modeling. He worked for Commonwealth Edision, GPUNuclear, Honeywell International, Warner Lambert, and Pfizer prior to joining Union University.

Improving Engineering Student Outcomes Assessment Through Performance Indicators

1. Introduction

All engineering programs have the same minimal set of student outcomes which are widely known as outcomes a-k by ABET currently.[1]Although these outcomes are subject to changes in the near future,[2]documenting the assessments of these outcomes is key to the compliance of criterion 3 for the accreditation of the Program.

For many years, our own system of assessing student outcomes produced acceptable results but in inconsistent manners because of its high degree of subjectivity (D.O.S) which depends largely on the definition of the rubrics and the users of the rubrics as shown in Table 1 below.

Table 1: Scoring Rubrics of student outcomes

Score	Definition
0	No evidence of achievement
1	Limited evidence of achievement
2	Adequate evidence of achievement
3	More-than-adequate evidence of achievement
4	Substantial evidence of achievement

There is a very good synopsis,[3]on the definitions of rubrics which also referred to the many reasons as to why rubrics should be employed.[4]

Our old rubrics as shown above lack the clarity as to what to give the scores on.The D.O.S could be explained as follow: for each of the outcome under consideration, the assessing faculty would examine the specific evidence (test, homework, project, paper, etc.) of student work and then judge the learning by a score in the range from 0 to 4 as guided by the above definitions. Another faculty looking at the same work may come up with a different score. Although a different score given by a different assessor is entirely expected, it is also expected that the assessors evaluate the same thing from the same view angle. Lacking that guideline for scoring leads to inconsistency.We wanted a different tool to reduce the D.O.S-induced inconsistencies while recognizing that they cannot be eliminated.

We set out to improve the assessing rubricsby designing a new set of performance indicators (PI). The new system is to improve consistency, reduce faculty workload, streamline record keeping, and maintain the current result.

2. The way it was as the problem state

In the old assessment system, we collected data and assessed student outcomes according to the following course-to-outcomes mapping (Table 2). A database by Access was established to keep track of the learning scores (a-k) categorized by students and by courses. The scores ranging from 0-4 according to the rubrics in Table 1 represent the degrees of learning as evaluated by the teaching faculty. Locally-developed test questions are among the mechanisms for outcome assessment.

a. Course-to-Outcomes Mapping

As shown by the course-to-outcomes mapping in Table 2 below, the system was established very conservatively to collect a lot of data from a lot of sources very regularly.

Table 2: Mapping of courses and student outcomes in the problem state

Courses	Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
101	✓				✓	✓		✓			
105						✓	✓		✓		✓
109									✓		✓
210	✓				✓		✓			✓	
240	✓		✓						✓		✓
250	✓	✓			✓		✓				
261	✓		✓		✓						✓
262	✓	✓			✓						✓
320	✓				✓			✓		✓	
330	✓						✓	✓		✓	
342	✓	✓		✓	✓		✓				✓
352	✓	✓	✓		✓		✓				
355	✓	✓			✓				✓		
360	✓								✓		✓
361	✓	✓	✓								✓
375	✓		✓		✓	✓					
405	✓	✓			✓		✓				✓
416	✓		✓				✓		✓		
455	✓				✓	✓		✓		✓	
456	✓		✓		✓		✓				✓
475	✓	✓	✓						✓		✓
491/492	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
498						✓		✓			
#	20	9	9	2	14	6	10	6	8	2	12
% of curriculum	87	40	40	9	61	26	43	26	35	22	52

Shaded courses represent the data collection activities in the Fall semester; The rest are in the Spring semester. After two ABET cycles, and in responding to the concerns from the faculty in the Department who felt overly burden administratively in doing ABET-related work, the Department sought to streamline the process in the spirit of continuous improvement.

3. The way it is as the desired state

As the desired state of the new student outcomes measuring tool, we set four goals: (1) we want to involve all academically mature students who are most likely to be in the program to graduate, (2) we want to minimize the number of evaluations but not to compromise the representativeness of the measurement, (3)we want to have buy-in from all faculty in the department, and (4) we want to maintain the existing results.

a. **Course-to-Outcomes Mapping**

Based on the above desired goals, the faculty went through the curriculum and chose the courses thatbest represent the sources of stated student outcomes. The revised course selection(except for one) represents students in the last two years in the curriculum. The associated data collection plan for each outcome, as shown below in Table 3 below, is to have at least one course in the engineering common core to ensure that all students regardless of their area of concentration, electrical engineering or mechanical engineering, are in the sample. The courses being listed below are to (1) illustrate the selection process in order to achieve the desired distribution of curriculum to be assessed, and (2)demonstrate the inclusivity of desired student population in the measurements.

Table 3: Identification of representative courses to measure student outcomes in the desired state

Outcomes	Evaluated by Courses		Students are from		
	Fall	Spring	MEC	EEC	General Core
A		EGR 330			√
A	EGR 355		√		
A	EGR 395			√	
A	EGR 475				√
B	EGR 342				√
B		EGR 352	√		
B		EGR 405		√	
C	EGR 361			√	
C	EGR 456		√		
C		EGR 492			√
D	EGR 342				√
D		EGR 492			√

E	EGR 320		√		
E		EGR 405		√	
E		EGR 492			√
F	EGR 101				√
F		EGR 492			√
F		EGR 498			√
G		EGR 105			√
G	EGR 342				√
G		EGR 492			√
H		EGR 498			√
I		EGR 352	√		
I	EGR 456		√		
I		EGR 492			√
J	EGR 361			√	
J	EGR 455		√		
J		EGR 498			√
K		EGR 250	√		
K		EGR 262		√	
K	EGR 475				√
K		EGR 492			√

Retooling the assessment method has positively reduced faculty administrative workloads by 70% from 101 course evaluations and evidence collections to a welcoming 31 as shown by Figure 1 below.

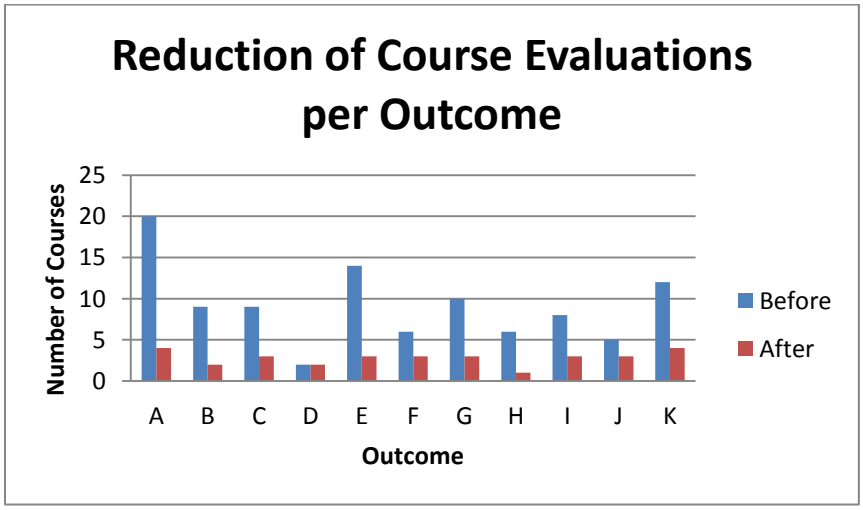

Figure 1: Number of courses used in the evaluation before and after the project

b. The performance indicators (PIs)

In addition to refining the sources for student outcomes collection to reduce faculty data collection efforts, we also aimed to reduce inconsistencies in assessing the student outcomes. This was done through a set of new performance indicators. The author was reminded of the many resourceful and excellent web sitesthat interested readers may want to consult for more information.[5,6,7,8]Applying the learning of the various workshopswas also evidenced in our redesign of the current PIs.[9,10]Consistency is not meant to have the same score by different assessors; it's looking at the same object at the same angle when doing the assessment.Below are some examples of rubrics with performance indicators that are being used in our Program. Together with the rest of the PIs, they represent significant leap toward improving our student outcomes assessment.

Performance indicator for outcome C: To assess the ability to design a system, component, or process to meet desired needs within realistic constraint as economic, environment, social, political, ethical, health and safety, manufacturability, and sustainability, the assessing faculty used to come up with learning score based on his or her "mental" picture regarding the students' work in the classroom during the semester. Now under our new PI system, the score will be based on whether, and how well, the students

- Work within realistic constraints established by the customer (internal or external) and good engineering practices.
- Carry out a methodical design process, and
- Meet the desired needs.

Performance indicator for outcome F: Another example of our improving the scoring guideline to measure the understanding of professional and ethical responsibilities is to write down the desired indicators. We now uniformly examine and evaluate whether, and how well, the students

- Recognize ethical issues and understand different ethical perspectives and concepts.
- Evaluate ethical issues that may occur in professional practice using professional code of ethics.
- Interact with industry, project sponsors, professional society, and community in a professional manner.

c. The results

The following four areas have been positive results of this improvement project:

i. The deviation of measurementsof student outcomes has been small. This was what we wanted to achieve as shown in the charts below. The upper chart shows the average of each outcome in a span of 4 years for the class of 2015. In this chart, the calculations of the average of the first 3 years were done

using the old rubrics (without written guidelines). The new rubrics were used only in the senior year of this class. The lower chart also shows the average of each outcome in the span of 4 years of the class of 2015. However, the new rubrics were used to calculate of the average of the first 3 years as well as the senior years.

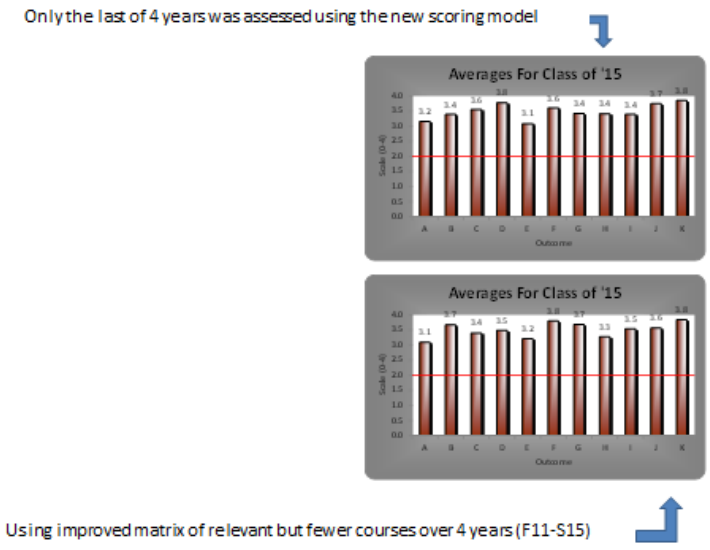

Figure 2: Measurements of student outcome before and after the project

Table 4: Spread in measurements between the old and new rubrics

Outcome	Old rubrics	New rubrics with PIs	% difference
A	3.2	3.1	3.1
B	3.4	3.7	8.8
C	3.6	3.4	5.6
D	3.8	3.5	7.9
E	3.1	3.2	3.2
F	3.6	3.8	5.6
G	3.4	3.7	8.8
H	3.4	3.3	2.9
I	3.4	3.5	2.9
J	3.7	3.6	2.7
K	3.8	3.8	0

The faculty assessed the results and approved the acceptability of the new tools.

ii. A general sense of consistencies has been established among the faculty in the Program in that the assessments of student outcomes now are being guided by established rubrics with specific performance criteria being tabulated.
iii. Administrative load has been noticeably reduced. Reducing the amount of data entry also has a side benefit in that it increases accuracy of the measurement by reducing potential errorof entering many data points.
iv. Faculty morale has been great. This implies better measurement.

4. Discussion

- The improvement project was really a response to faculty's concerns of lack of consistencies. Consequently, addressing these concerns has naturally enrolled the participation in the improvement project by the faculty. The key to faculty's eager acceptance of the new rubric project was in its design. It was faculty-led. Faculty empowerment was completely and sincerely done. The department head divided the set of a-k outcomes into several subsets and assigned faculty members into those subsets and set a time to finish the task (one month). The design of the project required a large chunk of each faculty's time investment. This was the biggest challenge! To facilitate this, the department leadership set a clear objective (we need performance indicators for each outcome) and a well-defined time frame (we need to get them done in 4 weeks).We found that specific group assignments and specific end-time were helpful with this kind of project to avoid a drawn-out event.
- Faculty in each group held "outcomes" meetings twice a week at the end of the workday to minimize disruption and to maximize the benefits of personal sacrifice. Each meeting had an end-time in itself and the scribe job was rotated each time. This was found to be very beneficial in this type of project which tends to have a lot of discussion. Writing things down in a summarized fashion can be overwhelmed and discouraging. Hence the benefits of rotation of responsibilities. We found that full faculty meeting during the one-hour monthly faculty meeting on the project of this nature was not suitable since it generated too much discussion for the limited time we had. It could not be a part of another meeting either. It needed to be a meeting by itself with focused attention.
- Small groups reported to full faculty for piecemeal approval as the PIs for an outcome or several outcomes were ready to be recommended. This was found to be beneficial because it gave closure, sense of progress and encouragement toward the end-zone scoring.
- It is true that placing a system in place is one thing, implementing it by the faculty is entirely another. In our case, though, that wasn't the situation sincethe project was something desired by the faculty, and then designed and birthed by the faculty. The implementation of the new system has been smooth for the same reason mentioned.

5. **Conclusions**

Performance indicators are very useful in establishing the much-needed rubrics for the measurement of student outcomes. Writing performance indicators requires focused efforts. Intention must be made to avoid a time-wasting drawn-out project. All faculty involvement is a must in setting goals and designing the assessment process. Reducing assessment loads is important; it starts with the right selection of the type of course and the type of students in the course.

Acknowledgements

This work was made possible only with substantial efforts, significant time investment and critical input from the engineering faculty in the department. Excellent leadership provided by the department Chair was absolutely essential to complete this continuous improvement project in a timely manner. Helpful and constructive comments from anonymous reviewers were sincerely appreciated.

References

1. http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/#outcomes viewed on March 18, 2016
2. http://www.abet.org/accreditation/accreditation-criteria/accreditation-alerts/ viewed on March 21, 2016
3. Myerhoff, L., *Rubrics: What are they and why should I use them?*seehttp://blogs.cornell.edu/cultureofevidence/2015/11/16/rubrics-what-are-they-and-why-should-i-use-them/viewed on March 18, 2016
4. Suskie, L. (2009). *Assessing student learning: A common sense guide.* San Francisco, CA: Jossey-Bass, Inc.
5. Measuring Student Learninghttp://cte.cornell.edu/teaching-ideas/assessing-student-learning/measuring-student-learning.html#2
6. Design project rubric http://www.engr.wisc.edu/cmsdocuments/DesignProjectRubric.pdf viewed on March 18, 2016
7. Presentation rubric http://www.engr.wisc.edu/cmsdocuments/PresentationRubric.pdfviewed on March 18, 2016
8. Research paper/project http://www.engr.wisc.edu/cmsdocuments/ResearchPaperProjectRubric.pdf Viewed on March 18, 2016
9. Rogers, G., *Developing Rubrics*, 2010 ABET Webinar on CD, Baltimore, MD
10. Self-Study Displays. 2014 ABET Symposium, Pittsburgh, PA