AC 2007-2286: A DIRECT ASSESSMENT TECHNIQUE THAT WORKS

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A Direct Assessment Technique that Works

Abstract

The development and use of direct assessment techniques using embedded indicators has become more prevalent at this institution over the last two years in response to requirements to provide more meaningful assessment data without incurring additional faculty resources. A specific technique linking student grades to the assessment of program outcomes has been used successfully in two civil engineering courses with good success. This paper presents a revised procedure that serves to address previously expressed concerns related to mathematical processes within the assessment technique.

The assessment technique is constructed within a spreadsheet and is easy to modify for use in any course. Inherent to this assessment technique is a mapping of specific student activities, whether as part of a project or other graded assignment, to specific program outcomes. The mapping involves the assignment of a number between one (weak mapping) and five (strong mapping) by experienced faculty members who have taught the course at least once and are knowledgeable about both the course and its relation to the program outcomes. Included within the spreadsheet is a standard grading breakdown which lists the specific student activities and their relative point values. After assignment of points for each activity, the spreadsheet combines the grade values and the mapping values to determine an assessment of each program outcome.

Another meaningful aspect of the technique is the determination of the validity of each program outcome assessment value. The validity number allows the instructor to determine which program outcomes need either increased emphasis or the inclusion of additional student activities in the assessment. The number also assists instructors in reallocating resources or student effort from strongly assessed outcomes to outcomes where the validity of the assessment may be questionable.

This paper includes the discussion of data collected over two semesters for the CE Capstone Design Course and addresses the use of a similar system in a senior- level construction management course.

Introduction

For years, educators have been trying to find innovative ways to capture what their students have learned to assess the effectiveness of their programs. Some strictly rely on student end-of-course critiques. Others rely solely on grades and some on a combination of the two. A method used in CE492, Design of Structural Systems, at the United States Military Academy (USMA) includes the use of embedded indicators to directly assess students' abilities to achieve each of the 17 Civil Engineering (CE) Program Outcomes. Embedded indicators have been shown previously to provide a better assessment of student work.[1-4]

The development and use of direct assessment techniques at the United States Military Academy has become more prevalent over the last two years in response to requirements to provide more meaningful assessment data without incurring additional faculty resources. CE492 is the ideal course to discuss the application of this technique, because it is the CE Capstone Course and provides a venue in which all of the 17 CE Program Outcomes can be directly assessed. The course challenges students with a comprehensive design problem requiring the use of design codes and specifications and the application of all skills learned throughout their CE studies. It provides an ideal platform for the mapping of student performance to CE program outcomes. With little additional faculty effort, this technique has been used successfully in CE492 and another course taken by students not majoring in CE.[5] The purpose of this paper is to address previously expressed concerns about the mechanics within the direct assessment technique and to present a revised method.

Original Assessment Method

The concern expressed about the original assessment technique involved the use of a one to five rating scale as an intermediary step to define the assessment of each outcome as shown in Table 1 below. In the previous method, the initial "Measure of Assessment" was based on the student grade on a particular event in the course and was a percent value between 0 and 100. The initial value was then converted to a "Scaled Assessment" value according to Table 1 below. This intermediate step could potentially lead to the misrepresentation of the final assessment of a program outcome by as much as 10%.

Table 1 – Course Assessment Template

Measure of Assessment	Scaled Assessment	Description of Assessment
90% - 100%	5	Excellent
80% - 90%	4	Good
70% - 80%	3	Marginally Satisfactory
65% - 70%	2	Marginally Unsatisfactory
0% - 65%	1	Unsatisfactory

This paper includes the discussion of data collected over two semesters for CE492 and addresses the use of a similar system in CE450, Construction Management and Infrastructure Development taught to students not majoring in civil engineering. It compares the resulting assessments using the originally suggested technique and a revised technique that maintains a percentage rating out of 100 throughout the process.

The technique used within the CE Program at USMA is constructed within a spreadsheet and is easy to modify for use in any course. Inherent to this assessment technique is a mapping of specific student activities to program outcomes. The mapping involves the assignment of a number between one (weak mapping) and five (strong mapping) by faculty members who have taught the course at least once and are knowledgeable about both the course and its relation to the program outcomes. This step normally requires about an hour and is the only subjective step in the process. For example, as part of the 10 percent design submission for CE492, students are required to develop architectural floor plans for a given building scenario. Table 2 lists the USMA CE Program Outcomes. As shown in Table 3, the instructor mapped the task to the

program outcomes by assigning a five to Outcome 2, a three to Outcomes 1 and 6, a two to Outcome 13, and a one to Outcome 7, 8, 14, and 15. This specific task was only one of 109 design requirements testing student knowledge during the semester in the capstone course.

Table 2 – USMA Civil Engineering Program Outcomes

Ref. #	CE Program Outcomes
O1	Graduates can apply the engineering thought process to design civil engineering components and systems.
O2	Graduates demonstrate creativity, in the context of engineering problem-solving.
O3	Graduates are proficient in the structural, environmental, hydrology & hydraulic design, and geotechnical discipline areas of civil engineering.
O4	Graduates are proficient in mathematics, calculus-based physics, and general chemistry.
O5	Graduates can design and conduct experiments, and analyze and interpret data.
O6	Graduates can function effectively on multidisciplinary teams.
O7	Graduates demonstrate an appreciation of the roles and responsibilities of civil engineers and the issues they face in professional practice.
O8	Graduates can use modern engineering tools to solve problems.
O9	Graduates can write effectively.
O10	Graduates can speak effectively.
O11	Graduates demonstrate knowledge of contemporary issues.
O12	Graduates have the broad education necessary to understand the impact of engineering solutions in a global and societal context.
O13	Graduates are prepared for and motivated to pursue continued intellectual and professional growth – as Army officers and engineers.
O14	Graduates can apply knowledge in a specialized area related to civil engineering.
O15	Graduates can explain the elements of project management, construction, and asset management.
O16	Graduates can explain business and public policy and administration fundamentals.
O17	Graduates can explain the role of the leader and leadership principles and attitudes.

Once the mapping values were assigned to each of the 109 tasks, total mapping values were obtained for each outcome by summing the squares of all the mapping values for each program outcome. For Outcome 1, the sum of the squares of the 35 mapping values was 294, which was then divided by 25 to determine the validity of mapping for the program outcome. The value 25 represents five squared, providing greater emphasis on tasks with a strong mapping to program outcomes. In other words, it would take multiple tasks with weaker mapping values to equal one task with a very strong mapping value. In the example for Outcome 1, the reliability number is 11.8, or 294 divided by 25. This allows the instructor to determine which program assessment values are perhaps less valid or which outcomes potentially require a reallocation of resources or student effort from outcomes with more valid assessment results to outcomes where the validity of the assessment may be questionable. For this technique, any outcome with a measure of greater than or equal to one was considered acceptably valid.

Table 3 – Mapping Student Activities to Program Outcomes

	Design Requirements:	Civil Engineering Program Outcomes Mapping with Requirements: 5 (High) - 1 (Low)																
		O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17
10% Design	Admin Requirements						1											
	Title Sheet																	
	Executive Summary						1			3								
	Drawing List																	
	Notes Page						2											
	Project Scope	4					2	4		2				2		3	2	
	Facts and Assumptions	4				1	1			2			1	2				
	Needs Analysis	4				2	2			3			1	2			1	
	Discussion and Results	4	1			2	3	2		4			5	3				
	Existing Site Plan													1				
	Site Use Plan	3	3	1			3	1	1					2	1	1	1	
	Site Prep and Demo Plan								1							1		
	Exterior Architectural Elevations		4						1					1		1		
	Architectural Roof Plan						1		1					1				
	Architectural Floor Plans	3	5				3	1	1					2	1	1		
	Life Safety Floor Plans	1	1					1										
	Typical Details	1	1											1		1		
	Arch. Floor Plan & Access/Egress Calcs	1			1	1			1						1			
	Load Analysis	2		3	2				1						3			
	Soil and Foundation Plan Calculations			3		1		1	1						3			
	Drainage Plan Calculations	3		3	2	1		1	2						3			
	Environmental Considerations		3	3	1	1	1	2		2		2	2	1	1			
	Cost Estimates							1							1	1		
	Documentation (coordination with key players)						3	1								4	4	3
	Bonus:																	

Included within the spreadsheet is a standard grading breakdown which lists the specific student activities and their relative point values. This breakdown provides the initial listing for mapping with program outcomes. After assignment of points for each activity, the spreadsheet combines the grade values and the mapping values to determine an assessment of each program outcome. As shown in Table 4, Team #1 earned 27 out of 35 possible points (77 percent) on their architectural floor plan submission. Their earned percentage is then multiplied by the instructor-assigned mapping value of 5 to determine a grade-adjusted assessment value of 3.9.

Table 4 – Grade Adjusted Assessment of Program Outcomes

	Design Requirements:	Possible Points	Points Earned	Earned %	Civil Engineering Program Outcomes Grade-Adjusted Assessment															
					O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17
10% Design	Admin Requirements	15	13.5	90%						0.9											
	Title Sheet	5	5	100%																	
	Executive Summary	5	5	100%						1.0			3.0								
	Drawing List	5	5	100%																	
	Notes Page	5	5	100%						2.0											
	Project Scope	5	5	100%	4.0					2.0	4.0		2.0				2.0		3.0	2.0	
	Facts and Assumptions	5	5	100%	4.0				1.0	1.0			2.0			1.0	2.0				
	Needs Analysis	5	5	100%	4.0				2.0	2.0			3.0			1.0	2.0			1.0	
	Discussion and Results	15	13	87%	3.5	0.9			1.7	2.6	1.7		3.5			4.3	2.6				
	Existing Site Plan	5	4	80%													0.8				
	Site Use Plan	10	6.5	65%	2.0	2.0	0.7			2.0	0.7	0.7					1.3	0.7	0.7	0.7	
	Site Prep and Demo Plan	5	0	0%								0.0							0.0		
	Exterior Architectural Elevations	20	17	85%		3.4						0.9					0.9		0.9		
	Architectural Roof Plan	5	1.5	30%						0.3		0.3					0.3				
	Architectural Floor Plans	35	27	77%	2.3	3.9				2.3	0.8	0.8					1.5	0.8	0.8		
	Life Safety Floor Plans	20	4	20%	0.2	0.2					0.2										
	Typical Details	15	6	40%	0.4	0.4											0.4		0.4		
	Arch. Floor Plan & Access/Egress Calcs	15	0	0%	0.0			0.0	0.0			0.0						0.0			
	Load Analysis	15	10	67%	1.3		2.0	1.3				0.7						2.0			
	Soil and Foundation Plan Calculations	10	10	100%			3.0		1.0		1.0	1.0						3.0			
	Drainage Plan Calculations	15	12.5	83%	2.5		2.5	1.7	0.8		0.8	1.7						2.5			
	Environmental Considerations	5	5	100%		3.0	3.0	1.0	1.0	1.0	2.0		2.0		2.0	2.0	1.0	1.0			
	Cost Estimates	5	3	60%							0.6							0.6	0.6		
	Documentation (coordination with key players)	5	4.5	90%						2.7	0.9								3.6	3.6	2.7

The assessment of an outcome is accomplished for each group by summing the grade-adjusted assessment scores for each CE Program Outcome and dividing that value by the sum of mapping points to determine a percentage. At this point in the original technique, the grade-adjusted

assessment percentages for each team were then translated into the one to five scale shown in Table 1 ranging from unsatisfactory to excellent. As shown in Table 5, the grade-adjusted assessment percentage of 68 percent (55.7 divided by 82) for Outcome 1 (O1) earned Team #1 a two (marginally unsatisfactory). The value 11.1 for O1 indicates that the assessment is valid since the value is greater than 1.0.

Table 5 – Team #1 Assessment of Standards

Assessment of Standard																
55.7	26.2	59.0	18.0	8.2	49.7	35.6	24.5	32.2	13.1	13.4	15.4	51.2	52.4	33.7	17.7	11.3
68%	75%	70%	67%	82%	78%	77%	61%	72%	87%	89%	90%	81%	67%	70%	84%	87%
2	3	3	2	4	3	3	1	3	4	4	5	4	2	3	4	4
11.1	3.9	9.1	2.1	0.6	5.8	2.7	3.0	4.8	2.4	1.6	1.9	5.0	10.2	5.2	2.0	1.6
O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17

A final scaled assessment score was obtained for a CE Program Outcome by averaging the assessment scores from each team. Evaluating the results from these last two steps suggested that the translation of the percentage values into a one-to-five scale could remove much of the accuracy of the assessment. A change to correct this problem is addressed in the next Section.

Recommended Change to the Original Method

To improve the effectiveness of the assessment tool, the translation of the grade-adjusted assessment score into the one-to-five assessment of standard scale was removed. This intermediate step was unnecessary and created two major issues that inhibited the effectiveness of the assessment.

First and most importantly, use of the one to five scale assigns a generic digital value to a range of percentages, resulting in inaccurate results. A group that averages 89 percent on a program outcome and a group that averages 79 percent on the outcome contribute a four and a three to the program outcome criteria average respectively. The criteria average would be a 3.5, resulting in a measured assessment of "marginally satisfactory." Using the revised method of skipping the intermediate scale conversion would result in a group average of 84 percent. This ultimately changes what would have been a "marginally satisfactory" measure of assessment to a more accurate "good" one.

The other major issue with the one to five scale is it sets an unrealistic bar to achieve excellence in a program outcome by unintentionally shifting the scale towards the low end. For example, if 6 of 12 groups earn 100 percent (converting to a fives) on a program outcome, while the other six groups earn 89 percent (converting to fours), the lasting impression for that program objective is that students are good (criteria average of 4.5). However, leaving all of the 12 group scores as a percentage would result in an overall average of 94 percent, which should be a course-wide assessment of "excellent."

Results of the Modification

To prove this point, data from CE492 from 2005 and 2006 were analyzed using both the original technique and the change recommended in this paper. The impact on the average assessment of

each program outcome was significant. As shown from the 2005 CE492 data in Table 6 and Table 7, half of the outcomes improved to a higher criteria average level of assessment once the one to five scales were eliminated as an intermediate step. Looking at Outcome 2, the one to five scale provides a 3.7 criteria average, which yields a "marginally satisfactory" measure of assessment at 74 percent (3.5 divided by 5). Skipping the one to five scale and using the modified process yields a criteria average of 82 percent and gives a "good" measure of assessment. That is an 8 percent difference in assessment, giving the instructor a much different perspective on how to view student performance.

Table 6 – CE492 Program Outcomes Assessment, 2005 Original Method

CE492 Assessment of the CE Division Program Outcomes

Team #	EDP Grade	Assessment : 5 (High) - 1 (Low)																Group Average
		O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	
1	73.4%	2	3	3	2	4	3	3	1	3	4	4	5	4	2	3	4	4	3.2
2	100.0%	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0
3	80.4%	3	4	3	4	4	4	4	3	5	5	5	4	4	3	4	4	5	4.0
4	95.2%	5	5	4	4	5	5	5	4	5	5	5	4	5	4	5	5	5	4.7
5	103.6%	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5.0
6	77.9%	3	3	4	3	4	3	3	3	3	4	5	5	4	3	4	4	4	3.6
7	80.6%	3	4	3	1	3	4	3	2	4	4	5	5	4	2	4	4	4	3.5
8	71.7%	1	1	1	1	2	2	2	1	2	4	3	3	3	1	3	3	3	2.1
9	78.0%	3	3	3	2	2	3	3	3	4	5	4	4	4	3	4	4	4	3.4
10	99.6%	5	4	4	4	5	5	4	4	5	5	3	4	5	4	5	5	5	4.5
Criteria Average		3.5	3.7	3.5	3.1	3.9	3.9	3.7	3.1	4.1	4.6	4.4	4.4	4.3	3.2	4.2	4.3	4.4	
Measure of Mapping (>1.0 is Acceptable)		11.1	3.9	9.1	2.1	0.6	5.8	2.7	3.0	4.8	2.4	1.6	1.9	5.0	10.2	5.2	2.0	1.6	

Assessment Average	3.9
Mapping Average	4.3
EDP Average	86.1%

Table 7 – CE492 Program Outcomes Assessment, 2005 Modified Method

CE492 Assessment of the CE Division Program Outcomes

Team #	EDP Grade	Assessment : 5 (High) - 1 (Low)																Group Average
		O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	
1	73.4%	68%	75%	70%	67%	82%	78%	77%	61%	72%	87%	89%	90%	81%	67%	70%	84%	87%	77%
2	100.0%	92%	94%	92%	93%	96%	92%	94%	91%	95%	93%	96%	93%	94%	93%	97%	96%	95%	94%
3	80.4%	79%	82%	78%	80%	89%	84%	83%	73%	95%	97%	91%	90%	88%	77%	89%	90%	92%	86%
4	95.2%	90%	90%	88%	87%	95%	90%	91%	87%	96%	94%	92%	90%	91%	87%	93%	97%	95%	91%
5	103.6%	93%	97%	93%	92%	95%	91%	94%	91%	96%	100%	94%	98%	95%	93%	95%	98%	98%	95%
6	77.9%	73%	75%	80%	76%	81%	77%	80%	73%	77%	83%	94%	92%	82%	77%	90%	87%	88%	82%
7	80.6%	71%	83%	72%	64%	74%	82%	78%	68%	84%	90%	91%	90%	83%	68%	84%	86%	89%	80%
8	71.7%	60%	59%	63%	60%	67%	68%	66%	61%	66%	84%	79%	73%	74%	62%	75%	75%	77%	69%
9	78.0%	73%	79%	76%	70%	67%	78%	80%	74%	87%	93%	89%	81%	84%	75%	85%	82%	85%	80%
10	99.6%	90%	87%	84%	85%	91%	93%	89%	87%	94%	101%	78%	87%	93%	85%	92%	96%	98%	90%
Criteria Average		79%	82%	80%	77%	84%	83%	83%	77%	86%	92%	89%	88%	86%	78%	87%	89%	91%	
Measure of Mapping (>1.0 is Acceptable)		11.1	3.9	9.1	2.1	0.6	5.8	2.7	3.0	4.8	2.4	1.6	1.9	5.0	10.2	5.2	2.0	1.6	

Assessment Average	84%
Mapping Average	4.3
EDP Average	86.1%

Furthermore, five of the ten groups had a higher average assessment for all outcomes than originally indicated. The course average assessment was also higher, placing the overall course assessment as being "good" instead of "marginally satisfactory." One would expect the overall assessment to be more than just satisfactory considering the overall course average on the EDP was 86.1 percent. An instructor looking at the results of the original 2005 method would likely feel the need to make changes in instruction since eight program outcomes received mediocre results. If using the modified, more accurate method, the instructor could shift effort that could

have been wasted making potential unnecessary changes to curriculum. As Table 7 indicates, there were only four outcomes to which the instructor might devote more attention during the next semester the course is taught.

Analyzing the 2006 data (Table 8 and Table 9), 11 of the 17 outcomes increased their measure of assessment, with eight of them increasing from a "marginally satisfactory" assessment to "good." This dramatic assessment change could effect the amount of change or lack thereof an instructor may make to the course.

Table 8 – CE492 Program Outcomes Assessment, 2006 Original Method

CE492 Assessment of the CE Division Program Outcomes

Team #	EDP Grade	Assessment : 5 (High) - 1 (Low)																	Group Average
		O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	
1	91.3%	4	4	4	4	4	4	4	3	5	5	5	5	4	4	4	5	5	4.3
2	95.8%	4	4	4	4	4	4	4	4	4	5	5	4	4	4	5	4	5	4.2
3	94.7%	4	4	4	4	3	4	4	4	4	5	4	4	4	4	4	4	4	4.0
4	74.9%	3	2	3	3	3	3	3	2	5	5	4	4	4	3	4	4	4	3.5
5	73.7%	2	2	2	1	3	2	3	1	4	4	4	4	3	1	3	2	1	2.5
6	88.3%	4	4	3	3	3	4	4	3	5	5	5	5	4	3	4	4	4	3.9
7	89.4%	4	4	4	4	4	4	4	4	5	4	5	4	4	4	4	5	5	4.2
8	79.2%	3	4	3	2	3	4	4	2	4	4	4	4	4	3	5	5	5	3.7
9	91.1%	4	5	4	4	5	5	4	4	5	5	5	5	5	4	5	5	5	4.6
10	71.1%	2	3	1	2	2	2	3	1	4	4	4	4	3	1	3	1	1	2.4
11	89.1%	4	5	4	4	4	4	4	4	5	5	5	5	5	4	4	3	3	4.2
12	88.9%	3	2	2	1	2	3	3	3	4	4	1	3	3	1	4	4	4	2.8
Criteria Average		3.4	3.6	3.2	3.0	3.3	3.6	3.7	2.9	4.5	4.6	4.3	4.3	3.9	3.0	4.1	3.8	3.8	
Measure of Mapping (>1.0 is Acceptable)		11.8	4.0	9.1	2.1	0.6	6.7	3.4	3.0	5.2	2.4	1.6	1.9	5.2	10.2	6.5	3.2	2.3	

Assessment Average	3.7
Mapping Average	4.7
EDP Average	85.6%

Table 9 – CE492 Program Outcomes Assessment, 2006 Modified Method

CE492 Assessment of the CE Division Program Outcomes

Team #	EDP Grade	Assessment : 5 (High) - 1 (Low)																	Group Average
		O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	O16	O17	
1	91.3%	88%	89%	83%	86%	89%	88%	88%	80%	94%	92%	92%	95%	89%	83%	88%	93%	95%	89%
2	95.8%	88%	88%	89%	90%	85%	83%	90%	85%	87%	96%	92%	90%	89%	87%	90%	89%	91%	89%
3	94.7%	81%	90%	86%	82%	76%	89%	89%	86%	87%	92%	90%	87%	88%	85%	89%	86%	85%	86%
4	74.9%	76%	67%	75%	74%	76%	77%	79%	65%	92%	93%	90%	86%	81%	73%	85%	85%	89%	80%
5	73.7%	68%	70%	68%	61%	74%	69%	75%	62%	84%	81%	89%	87%	80%	63%	74%	69%	65%	73%
6	88.3%	81%	85%	78%	78%	74%	87%	88%	76%	92%	95%	93%	90%	85%	79%	87%	86%	88%	85%
7	89.4%	83%	84%	84%	84%	85%	87%	89%	83%	92%	88%	91%	88%	86%	83%	90%	91%	92%	87%
8	79.2%	71%	81%	72%	68%	79%	85%	85%	67%	86%	86%	87%	83%	82%	72%	92%	92%	93%	81%
9	91.1%	88%	91%	88%	86%	91%	91%	90%	85%	96%	93%	92%	95%	91%	86%	91%	93%	95%	91%
10	71.1%	68%	74%	64%	67%	68%	66%	70%	58%	86%	82%	88%	81%	73%	64%	71%	63%	61%	71%
11	89.1%	87%	96%	82%	81%	88%	84%	87%	80%	95%	94%	93%	93%	91%	80%	85%	79%	80%	87%
12	88.9%	75%	70%	66%	55%	69%	79%	70%	71%	86%	86%	63%	75%	79%	64%	82%	80%	81%	74%
Criteria Average		80%	82%	78%	76%	80%	82%	83%	75%	90%	90%	88%	88%	84%	77%	85%	84%	85%	
Measure of Mapping (>1.0 is Acceptable)		11.8	4.0	9.1	2.1	0.6	6.7	3.4	3.0	5.2	2.4	1.6	1.9	5.2	10.2	6.5	3.2	2.3	

Assessment Average	83%
Mapping Average	4.7
EDP Average	85.6%

A good example of the impact lies in Outcome 8 from the 2006 spreadsheet.[6] Using the original method, the instructor would see a course wide average of 2.9, indicating students demonstrated "marginally unsatisfactory" work when using modern engineering tools to solve problems. However, the real reason the criteria average ended up below three was due to the interim step, where percentages were translated into the one-to-five scale. The true criteria average for

Outcome 8 was 75 percent, which raised the assessment to marginally satisfactory. Maybe sweeping changes aren't required with regards to using modern engineering tools. Maybe only subtle modifications are necessary, and the more accurate assessment model helps the instructor make that decision more effectively.

Finally, the modified spreadsheet allows a course to achieve an assessment of excellent. Teachers and students alike strive to achieve greatness, which was near impossible to achieve prior to the modification as indicated in Table 3 and Table 4. In fact, over the two year period, the highest assessment using the one to five scale was a 4.6, which only met the criteria for a "good" assessment. The modified system recognized where excellence was achieved. Four outcomes were assessed as excellent over the two year period. This new technique helped capture those areas where the instructor can save time when preparing for the next iteration of the course, since it is unlikely any significant modifications would be necessary where excellence is already accomplished.

Conclusions

The use of embedded indicators as a direct assessment of student work serves many purposes. It allows instructors to save time by reducing the amount of additional work required in administering separate surveys to determine achievement of program outcomes. It gives the instructors specific areas to improve the quality of the course, and it directly connects student performance to program outcomes. The most important aspect of the tool, however, is that it must provide accurate assessment feedback in order for instructors to make sound decisions with regards to the future of the course. The recommendations made in this paper will increase the accuracy of the resulting assessments and simplify the original spreadsheet. Continued use of this tool will help the instructors in CE492 as well as the numerous prerequisite courses identify areas of weakness and develop ways to eliminate them as they strive to prepare their students to achieve excellence in all 17 Program Outcomes. In essence, using embedded indicators as a direct assessment of student learning can feed into the assessment of an entire engineering program, as discussed in "A Technique for Program-Wide Direct Assessment of Student Performance".[7]

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