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Successful Use of Performance Indicators to Assess Student Outcomes

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Introduction

Well-written Student Outcomes (SOs) are a vital part of a successful improvement process. However, the SOs are relatively broad statements on what students are expected to know. Performance Indicators (PIs) provide more specific actions that may be used for direct measurement of SOs, and they are useful tools for assessing the degree to which students successfully achieve subsets of each SO. During a recent reaccreditation by ETAC/ABET, several engineering technology programs demonstrated successful use of PIs for outcomes assessment and improvement processes.

Rubrics have been developed as tools to provide direct measurement of student performance in each of the SOs. The rubrics were designed to be used primarily in upper-level courses that were well-aligned with the student outcomes. Instructors selected student work representative of a particular SO in their course. The selected work depended on the type of course, and it typically included items such as oral presentations, written lab reports, or problem solutions from exams, quizzes, or homework assignments. It was most effective to complete rubric scores for student work while grading or as soon as possible afterward.

Development of Performance Indicators

Most of the work in this paper builds upon the fundamentals presented at ABET Program Assessment Workshops [1][2]. The general concepts presented here are not new; similar work has been done in multiple programs at other universities [3]. What makes this work unique is that each Performance Indicator (PI) has been written to assess the unique outcomes delivered locally at this institution. Faculty in the program wrote each PI with input from instructors in corresponding courses. There were no specific guidelines for selecting and developing the wording of each PI; they were written over time with knowledge gained from attending ABET workshops and ASEE conferences.

The precise wording of each PI was central to the successful use of the rubrics. Each rubric was limited to one page with three to five concise PIs that captured the vital aspects of the Student Outcome (SO). Proper selection of the verbs in each PI was a very important aspect of defining the expectation of students. The authors developed the PIs and then got feedback from the instructors who used the rubrics. Several examples are presented below.

Consider the SO in computer-aided design: *Generate computer-aided engineering graphics using commercial packages* [4]. The four corresponding PIs are:

PIa. Create two-dimensional drawings
PIb. Construct geometry for components and assemblies
PIc. Dimension and tolerance geometric features
PId. Create solid models and visualize spatial geometry

As another example, consider the SO for communication skills: *Communicate effectively, both orally and in writing*. This has been assessed more effectively by separating the outcomes for oral and written communication [5].

The four PIs for oral communication are:

PIa. Speak with proper language and effective verbal communication
PIb. Organize the content in a logical fashion
PIc. Provide graphical illustrations
PId. Identify and explain the topic with technical depth

The five PIs for written communication are:

PIa. Organize the content with appropriate methodology
PIb. Identify and explain the topic with appropriate technical depth
PIc. Write with proper language and correct grammar
PId. Provide graphical illustrations
PIe. Utilize quality and quantity of external references and resources

The PIs are essentially subsets of each SO, and so they provide more specific detail required to assess student performance. Each PI was evaluated with performance levels on a scale of one to four: *1 – Not acceptable, 2 – Below standards, 3 – Meets standards, 4- Exemplary*.
This simplified scale helped to maintain consistency among instructors, and it forced a decision between acceptable (meets standards) and unacceptable (below standards) performance.

Each performance level contained a brief, thorough description of the expectations, clarifying the differences between the levels. The intent was to provide enough detail to distinguish between levels, while giving flexibility for use in evaluating student work in different projects and courses. These descriptions were documented in the rubrics, each of which were intentionally restricted to a single page [4][5]. These references explain the processes used to create and use the rubrics. For the sake of completeness, a sample rubric is included in Appendix A.

Using Performance Indicators to Assess Student Outcomes

Instructors selected student work representative of a particular Student Outcome (SO) in their course. Because instructors were assessing SOs in their own course, it is possible that the instructors were biased in selecting student work. For programs with more faculty resources, it may reduce bias if faculty selected student work in courses taught by others. Ideally, assessment should be done by someone else besides the instructor, but this is not realistic for our program.

The total number of students, as well as the percentage of students, scoring 4, 3, 2, and 1 was used to evaluate aggregate performance of the group. Data from students not passing a course was not included; since they needed to retake the course, assessment data was collected when they passed. An initial benchmark was to have 70% of students scoring 3 or 4, indicating that at least 70% of the students met or exceeded acceptable standards. If less than 70% of students

scored 3 or 4, overall student performance was below the benchmark, indicating potential for improvement in that particular Performance Indicator (PI).

After obtaining baseline data from an initial evaluation, the 70% benchmark may have been changed, if appropriate. As the assessment process evolved, different SOs would then different benchmarks to reflect the level of difficulty in the specific assessment tool. This process was documented in the self-study report with the intention of re-evaluating benchmarks. However, in retrospect, the benchmarks have not yet been changed. Instead, efforts have been concentrated on improving areas below the 70% benchmark.

Appendices B, C, and D provide sample summaries of Performance Indicator (PI) results and interpretations for the examples presented in the previous section. The top of each table lists the SO followed by the PIs designated by letters: PIa, PIb, PIc, etc. Each table lists the course, the semester(s), and the evaluator, who was typically the instructor for the course. The tool used for assessment was the relevant SO rubric. Results are summaries of the rubric scores, assessments of student work using the designated tool.

Results were evaluated against the benchmark. Aggregate student scores above the benchmark were considered strengths to retain. Aggregate scores below the benchmark were evaluated to identify potential areas for improvement. After comparison to benchmarks, evaluators documented ideas for improvement. During a recent ABET accreditation visit, the evaluators found these summary tables to be useful.

Discussion

It was generally easiest and quickest to assess SOs immediately after grading student work, while student performance is fresh in the evaluators mind. However, grades are not used in rating student performance because grades tend to rate students from highest to lowest scores, effectively comparing students to each other. The intent of the rubrics was to rate the performance of each student to the criteria predefined in the rubric. It would have been beneficial to record the number of students being assessed in the tables in Appendices B, C, and D. The sample size may impact interpretation of results. For example, in Appendix D, there were significantly fewer students in the summer than in fall and spring semesters.

Performance levels may be divided into three to six point scales and given labels such as basic-proficient-advanced. In this paper, PIs were assessed on a scale of 1-4. Others have effectively assessed PIs on a scale of 1-3, further simplifying the assessment process [6]. Having three levels of performance allows the instructor to easily map the grades to rubrics levels. Proposing a description for each level without any kind of overlapping among the performance levels is a difficult task. Therefore, three level of performance is considered an efficient and a simple approach.

The intent of this paper was to focus specifically on the use of PIs to assess SOs, but there were other important processes used for assessment and program improvements. For example, the Industrial Advisory Boards played a routine active role. Their input was particularly helpful for identifying improvements in areas when aggregate student performance was below benchmarks. Student surveys also provided indirect measures in various evaluations of the SOs. However, since most of the assessment was based on newly-developed rubrics, the PIs formed the fundamental basis for the assessment in this accreditation cycle. Further improvements could be identified by having students and advisory board members use the PIs to assess SOs. Their external perspectives would be beneficial since faculty have been so immersed in the process since inception.

Conclusion

It took an initial investment of time to create rubrics with descriptive Performance Indicators (PIs) for each Student Outcome, and some of the PIs were written after initial use in order to provide more effective assessment. However, once the PIs were included in single-page rubrics, they were relatively easy to use by a variety of instructors in different courses. Summarizing results and interpretations in tables provided a concise representation of the assessment which was very successful in maintaining ongoing ABET accreditation.

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Appendix A: Sample Rubric

SO4. Generate computer-aided engineering graphics using commercial packages

Course: Date: Evaluator:

Student Evaluated:

Project Evaluated:

Performance Indicators

Student demonstrated the ability to:	1 – Not acceptable	2 - Below standards	3 – Meets standards	4 - Exemplary	Score
a. Create two-dimensional mechanical drawings	Lack of critical errors, missing features, numerous errors	Incomplete description of geometry, ambiguous shapes, broken lines or gaps	Create accurate depictions of parts with minor errors, recreate existing drawings	Professional quality, no errors, provides additional detail to existing drawings	
b. Construct geometry for components and assemblies	Inadequate or incorrect representation of parts or assembly	Broken lines, gaps in geometry, unclear how parts fit into assembly	Parts and assemblies are clear, well documented with minor omissions	Very clear depiction of components and how they fit into assembly	
c. Dimension and tolerance geometric features	Many missing linear or angular dimensions, units not specified, lack of tolerances	Incomplete specification, missing linear or angular dimensions, unclear units, incorrect or inappropriate tolerances	Most tolerances and fits are specified using standards, includes most of the details, minor omissions	Complete details for size and shape, all tolerances and fits are specified correctly	
d. Create solid models and visualize spatial geometry	Model is incomplete or unclear, unable to depict spatial geometry	Unclear model boundaries, orthographic projections are incorrect or misaligned, not organized	Model is clear with minor details; accurate isometric, section, and auxiliary views; clear depiction	Complete detail, lifelike, high quality visualization, flawless multi-view projections, visibility of hidden features	

Appendix B. Summary of PI Results and Interpretations for CAD.

SO4. Generate computer-aided engineering graphics using commercial packages Performance Indicators (PI) PIa. Create two-dimensional drawings PIb. Construct geometry for components and assemblies PIc. Dimension and tolerance geometric features PId. Create solid models and visualize spatial geometry				
Course	C/MTC 162, Computer Aided Design			
Semesters	Fall 2012, Spring 2013, Fall 2013, Spring 2014			
Evaluators	Krecidlo, Sweeney			
Tool	SO4 Rubric			
Student Work	Overall class performance (assignments, mid-term test, and final exam)			
Results	**Fall 2012**	**Spring 2013**	**Fall 2013**	**Spring 2014**
PIa: % scored 3 or 4	100%	100%	100%	100%
PIb: % scored 3 or 4	100%	100%	100%	100%
PIc: % scored 3 or 4	94.4%	100%	100%	100%
PId: % scored 3 or 4	94.4%	95.2%	93.3%	88.9%
Benchmark	70% of students scoring 3 (meets standards) or 4 (exemplary)			
Strengths	Very few students were below standards. The current course deliver y, including active learning and real-world applications, was very effective at teaching students. Similar results were obtained for fall 2013 and spring 2014.			
Ideas for Improvement	Fall 2012: Devote more time to 3D. Since students find dimensioning difficult, have them critique each other's dimensioning techniques. Help them realize that dimensions must be easily understood by the person reading the drawing. Fall 2013: Previous semester scores for 3D modeling were lower, so spent additional 2 weeks on 3D modeling. This helped, but created issues with scales. Next semester, spend only 1 week on 3D. Spring 2013: Assign out-of-class group projects to encourage students to work together while learning how to coordinate their efforts using CAD. Expand the lessons on scales. Students were required to evaluate the labs completed by other students. Spring 2014: The class size was smaller, and so more topics were covered with new assignments. Plan to incorporate them into next semester's class. Added two drawing interpretation assignments. Although difficult, students thought this helped to increase their ability to read and interpret drawings.			

Appendix C. Summary of PI Results and Interpretations for Oral Communication.

SO6a. Oral communication Performance Indicators (PI) PIa. Speak with proper language and effective verbal communication PIb. Organize the content in a logical fashion PIc. Provide graphical illustrations PId. Identify and explain the topic with technical depth			
Course	MTC 420, Capstone Experience		
Semesters	Spring 2012, summer 2012, fall 2012		
Evaluator	Jones		
Tool	SO6a Rubric		
Student Work	Final project presentation and report		
Results	**Spring 2012**	**Summer 2012**	**Fall 2012**
PIa: % scored 3 or 4	100%	60%	88.8%
PIb: % scored 3 or 4	100%	60%	66.7%
PIc: % scored 3 or 4	100%	100%	44.4%
PId: % scored 3 or 4	100%	60%	22.2%
Benchmark	70% of students scoring 3 (meets standards) or 4 (exemplary)		
Strengths	In spring 2012, all students exceeded the benchmark.		
Ideas for Improvement	Observations: In summer 2012, only 5 students passed the course, and 2 of the 5 students earned a grade of C. Scores in summer and spring declined substantially. Poor oral communication was a reflection of overall performance on the projects. Improved project work may lead to better presentations. This may be accomplished by more frequent and more formal progress reports, including oral presentations throughout the semester. The end of fall semester tends to be busier than the end of spring semester. In the future, MTC 420 will not be offered in the fall. See if this improves performance.		

Appendix D. Summary of PI Results and Interpretations for Written Communication.

SO6b. Written communication Performance Indicators (PI) PIa. Organize the content with appropriate methodology PIb. Identify and explain the topic with appropriate technical depth PIc. Write with proper language and correct grammar PId. Provide graphical illustrations PIe. Utilize quality and quantity of external references and resources			
Course	MTC 420, Capstone Experience		
Semesters	Spring 2012, summer 2012, fall 2012		
Evaluator	Jones		
Tool	SO6b Rubric		
Student Work	Final project presentation and report		
Results	**Spring 2012**	**Summer 2012**	**Fall 2012**
PIa: % scored 3 or 4	100%	60%	0%
PIb: % scored 3 or 4	100%	100%	22.2%
PIc: % scored 3 or 4	100%	80%	77.8%
PId: % scored 3 or 4	100%	80%	55.6%
PIe: % scored 3 or 4	77.8%	40%	22.2%
Benchmark	70% of students scoring 3 (meets standards) or 4 (exemplary)		
Strengths	In spring 2012, all students exceeded the benchmark.		
Ideas for Improvement	The above comments for SO6a apply here. Check the performance on the other SOs for capstone projects to see if there's a correlation. Poor communication may be a reflection of poor effort on technical work of the capstone projects.		