AC 2010-359: SUCCESSFUL USE OF RUBRICS TO ASSESS STUDENT PERFORMANCE IN CAPSTONE PROJECTS

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Successful Use of Rubrics to Assess Student Performance in Capstone Projects

Abstract

Capstone Experience, MTC 420, is a required course for all Mechanical Engineering Technology (MET) students during their senior year. The capstone projects are intended to be culminating experiences, drawing upon a wide range of knowledge from courses in the curriculum. Students are responsible for written project specifications, planning and milestone identification, implementation of the work, an oral presentation, and a final written report.

Because these projects are so comprehensive, they provide an opportunity for faculty to assess a wide range of student learning that is directly related to program outcomes. For this reason, MET faculty developed a rubric for assessing capstone projects, as shown on the following page. The instructor rates each project in terms of ten attributes on a scale of one to four, providing a direct measure for assessment of program outcomes. The scale of one to four (1-Not Acceptable, 2-Below Expectations, 3-Meets Expectations, 4-Exemplary) was intentionally chosen so that the instructor had to make a clear decision as to whether or not expectations were met.

The rubrics were administered at the end of each semester, fall 2007 through spring 2009, and results were tabulated and analyzed to identify areas which were satisfactory and areas needing improvement. The measure of successful performance in each attribute was the percentage of students achieving a level of three or four. A benchmark of 70% was used to gage the level of success. If 70% of students scored a three or four, then the program was considered successful for that attribute. An interesting side-effect occurred when students were given copies of the rubrics at the beginning of the semester in fall 2008. This raised their awareness of expectations, especially in the non-technical areas such as teamwork and communication skills.

A simpler rubric was also used to evaluate students' mid-semester oral presentations. After the presentation, the instructor completed the rubric for each student using a binary scale (0-unsuccessful, 1-successful). The measure of satisfactory performance in each category was the percentage of students scoring "1." A benchmark of 70% was used to gage the overall level of success. If 70% of the students were successful, then the presentations were considered successful. Results from this rubric gave the instructor and students feedback, and the results also provided a basis for monitoring improvements that occurred during the second half of the semester.

The levels of success in the capstone rubric were documented and correlated with levels of achievement for six program outcomes for four consecutive semesters. In fall 2009, these results were accepted by TAC/ABET as part of the continuous improvement program in MET. Note that the rubrics were *not* used directly to assign grades; however, results gave the instructor useful insight for evaluating the projects and assigning grades. Although the rubrics took some initial effort to develop, it is now fairly easy to complete and analyze the results each semester as a routine part of the ongoing assessment processes.

Introduction and Overview

Rubrics have been used in general education courses for many years. They have proven to be very helpful for grading written papers and oral presentations, particularly for large classes or multiple sections. Recently, rubrics have been adapted for assessing student learning in technical courses.[1,2,3] Similar work has also been done on evaluating capstone projects using an industrial scale.[4]

Because these projects are so comprehensive, they provide an opportunity for faculty to assess a wide range of student learning that is directly related to program outcomes. For this reason, MET faculty developed a rubric for assessing capstone projects. The objective of this paper is to present this rubric, the data collected over two years, and an analysis of the results.

A blank rubric, shown in Table 1, is a one-page paper form that is completed by the instructor at the end of the semester. The instructor rates each project in terms of ten attributes on a scale of one to four, providing a direct measure for assessment of program outcomes. The scale of one to four (1-Not Acceptable, 2-Below Expectations, 3-Meets Expectations, 4-Exemplary) was intentionally chosen so that the instructor had to make a clear decision as to whether or not expectations were met.

Results and Discussion

The instructor completed a rubric for each student at the end of the semester, and results were tabulated and analyzed to identify areas which were satisfactory and areas needing improvement. The rubrics were administered in fall 2007 and spring 2008 to gain experience in analyzing results, and it was repeated in spring 2009.

The measure of successful performance in each attribute was the percentage of students achieving a level of three or four. A benchmark of 70% was used to gage the level of success. If 70% of students scored a three or four, then the program was considered successful for that attribute.

Table 2 summarizes the results for fall 2007. Six of the attributes were above the benchmark of 70% (depth, timeline, organization, discussion, oral presentation, and written report.) Four of the attributes below the benchmark are shown in boldface (innovation, methodology, references, and teamwork.) These attributes are below expectations and represent areas for improvement.

Table 3 summarizes the results for spring 2008. Eight of the attributes were either at or above the benchmark of 70% (depth, innovation, timeline, organization, methodology, discussion, oral presentation and written report.) Two of the attributes below the benchmark are shown in boldface (references and teamwork.) This indicates an improvement, compared to fall 2007, which is probably due to the fact that students were given a copy of the rubric at the beginning of the semester, so they had a better understanding of the expectations and standards. Although the rubric was initially developed to assess outcomes, it was found to increase the quality of students' work on the projects.

Table 1. Rubric for MET Capstone Projects

Student _____   Evaluator_____   Semester _____

Attribute	1-Not acceptable	2-Below expectations	3-Meets expectations	4-Exemplary	Score
Technical depth	Little use of college-level skills, unclear proposal	Lack of technical content, proposed goals were not completed	Use of skills from junior and senior courses, proposed goals completed	Advanced insight, exceeds goals of the project	
Innovation	Not original, simple, content limited to lower-level courses	Limited scope, reproduces existing concepts/analyses	Applies original ideas, novel design, insightful	Highly innovative, thorough investigation, sophisticated	
Timeline	Lacks self-ambition, delays proposal, weeks with no progress	Requires prompting, procrastinates, rush at end of semester	Consistent effort throughout semester, documented milestones	Superior effort throughout, meets or exceeds goals, expands project scope	
Organization, neatness	Illogical, sloppy, unclear	Awkward, difficult to follow	Logical, well documented	Highly professional, textbook quality	
Methodology	Excludes data, incomprehensible, extremely vague, unclear	Presents data without explanation, does not question data, analysis is flawed or inappropriate	Clearly evaluates data, thoroughly explains procedure, minor errors or omissions	Justifies decisions, documentation is complete, correct, and appropriate	
Discussion	Misrepresents, draws incorrect or no conclusions, lack of understanding	limited insight, misses key issues, inconclusive	Identifies critical issues, suggests improvements	Thorough evaluation, unique insight, examines inconsistencies	
References, resources	Does not collect external information, irrelevant sources, plagiarism, dishonesty	Insufficient research, limited use of sources, inadequate background research	Presents useful information of sufficient quality and quantity, correctly formatted	Collects extensive relevant information from a wide range of sources, validates findings	
Oral presentation	Brief, fails to persuade, lack of adequate illustrations, disjointed	Misconstructions, unclear, poor illustrations, focus on others' work	Persuasive, clear communication, effective use of illustrations	Succinct, clear, use of multimedia, coherent, focus on new understandings	
Written report	Grammar errors, misspelling, brief, misrepresents information	Poor grammar, excess verbiage, insufficient detail	Grammatically correct, thorough explanations, straightforward	Excellent blend of explanations and illustrations, full detail	
Teamwork	Works alone, argues without resolution, unwilling to cooperate, does not complete tasks	Unequal contributions, overreliance on others, needs reminding	Contributes equally, cooperates, works toward group goals, self-motivated	Values and encourages all members, coordinates efforts, provides appropriate leadership	

Table 2. Summary of Rubric Data, Fall 2007
Scores: 1 - Not Acceptable, 2 - Below Expectations, 3 - Meets Expectations, 4 - Exemplary

Student	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
1	3	2	3	3	2	3	2	3	3	2
2	4	4	4	4	4	4	4	4	4	4
3	2	1	2	2	1	2	1	2	2	1
4	3	2	3	3	2	2	2	2	3	3
5	3	2	3	3	3	3	3	3	3	4
6	3	4	4	4	3	4	3	4	4	3
7	4	4	4	4	4	4	4	4	4	4
8	3	3	3	4	3	4	3	4	4	4
9	3	2	3	3	3	3	3	3	2	1
10	3	2	3	3	3	4	3	3	3	4
11	2	2	3	3	2	2	2	3	3	3
12	4	4	4	4	4	4	4	4	4	4
13	3	2	2	3	2	3	2	3	3	2

Number of scores

	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
1	0	1	0	0	1	0	1	0	0	2
2	2	7	2	1	4	3	4	2	2	2
3	8	1	7	7	5	4	5	6	6	3
4	3	4	4	5	3	6	3	5	5	6

Number of scores 3 and 4

	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
	11	5	11	12	8	10	8	11	11	9
%	84.6	**38.5**	84.6	92.3	**61.5**	76.9	**61.5**	84.6	84.6	**69.2**

Table 3. Summary of Rubric Data, Spring 2008
Scores: 1 - Not Acceptable, 2 - Below Expectations, 3 - Meets Expectations, 4 - Exemplary

Student	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
1	3	3	4	4	3	3	2	3	3	4
2	3	1	2	1	1	2	1	2	1	1
3	4	3	3	4	3	4	3	4	3	4
4	3	3	3	4	4	3	3	3	3	3
5	4	3	3	4	4	4	4	4	3	2
6	4	3	3	4	4	3	2	4	3	1
7	4	3	3	4	3	4	4	3	4	4
8	4	3	3	3	4	4	1	3	3	0
9	4	4	3	4	3	4	2	4	2	4
10	4	2	3	3	3	4	3	3	2	2
Number of scores										
1	0	1	0	1	1	0	2	0	1	3
2	0	1	1	0	0	1	3	1	2	2
3	3	7	8	2	5	3	3	5	6	1
4	7	1	1	7	4	6	2	4	1	4
Number of scores of 3 and 4										
	10	8	9	9	9	9	5	9	7	5
%	100	80	90	90	90	90	**50**	90	70	**50**

On the attribute of references, the percentage of students scoring three or four dropped from 62% in fall 2007 to 50% in spring 2008. This may have been due to the nature of the projects in spring 2008; more students had "design and build" projects, so they did not do as much research. This identified another area for improvement. Students with "design and build" projects should be encouraged to do more research to learn from prior designs and avoid duplicating previous work. This may also lead to increased scores on the "Innovation" attribute.

Table 4 summarizes the results for spring 2009. All measured attributes were clearly above the benchmark, indicating an improvement over the past semesters. This presents an opportunity to "raise the bar" and consider the number of students scoring four. An interesting side-effect occurred when students were given copies of the rubrics at the beginning of the semester in fall 2008. This raised their awareness of expectations, especially in the non-technical areas such as teamwork and communication skills.

Table 4. Summary of Rubric Data, Spring 2009

Scores: 1 - Not Acceptable, 2 - Below Expectations, 3 - Meets Expectations, 4 - Exemplary

Student	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
1	3	3	3	3	3	3	3	3	*	4
2	4	4	3	3	3	4	3	4	*	4
3	4	4	4	4	4	4	4	4	3	4
4	4	3	3	4	3	3	3	4	3	3
5	3	3	3	3	3	3	3	3	3	3
6	3	3	3	3	2	3	2	3	*	3
7	3	3	3	3	2	3	2	3	*	3
8	4	3	4	4	4	4	3	4	*	4
9	4	3	3	3	3	4	3	3	*	3

Number of scores

	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
1	0	0	0	0	0	0	0	0		0
2	0	0	0	0	2	0	2	0		0
3	4	7	7	6	5	5	6	5		5
4	5	2	2	3	2	4	1	4		4

Number of scores of 3 and 4

	Depth	Innovation	Timeline	Organization	Methodology	Discussion	References	Oral	Report	Teamwork
	9	9	9	9	7	9	7	9		9
%	100	100	100	100	77.8	100	77.8	100	N/A	100

A simpler rubric was also used to evaluate students' mid-semester oral presentations, as shown in Table 5. After the presentation, the instructor completed the rubric for each student using a binary scale (0-unsuccessful, 1-successful). The measure of satisfactory performance in each category was the percentage of students scoring "1." A benchmark of 70% was used to gage the overall level of success. If 70% of the students were successful, then the presentations were considered successful. Results from this rubric gave the instructor and students feedback, and the results also provided a basis for monitoring improvements that occurred during the second half of the semester.

Table 5. Rubric for Mid-semester Oral Presentations

Before the presentation, submit a typed page with:
Your name(s), Descriptive title
Outline of the presentation
List of references, including URLs of websites used
Clearly cite all references to avoid plagiarism.

Grading Criteria	Points
Paperwork submitted	1
Use of illustrations to maximize the short presentation time	1
Clarity of presentation	1
Organization and neatness	1
Timeline for completing the work	1
Quality and quantity of references	1
Adhering to time constraints. (Set up in advance!)	1
Scope and depth of topic	1
Overall competence	2
Total	**10**

Conclusion

The capstone rubric has provided a systematic approach to evaluating student learning outcomes using direct measures. The levels of success in the capstone rubric were documented and correlated with levels of achievement for six program outcomes for two years. In fall 2009, these results were accepted by TAC/ABET as part of the continuous improvement program in MET. Note that the rubrics were *not* used directly to assign grades; however, results gave the instructor useful insight for evaluating the projects and assigning grades. Although the rubrics took some initial effort to develop, it is now fairly easy to complete and analyze the results each year as a routine part of the ongoing assessment processes.

Bibliography

1.   K. Reid & E. Cooney, "Implementing Rubrics as Part of an Assessment Plan," Best Assessment Processes VIII: A Working Symposium, Terre Haute, IN, February 27-28, 2006.
2.   S. Scaffer et.al., "Assessing Multi-disciplinary Teams," Best Assessment Practices Symposium, Indianapolis, IN, April 3-4, 2009.
3.   J. Hanson, "Rubrics: Helping You and Students Perform Better," Best Assessment Practices Symposium, Indianapolis, IN, April 3-4, 2009.
4.   V. Ulrich, "Rating Capstone Design Students on an Industrial Scale," 2008 ASEE Annual Conference, Pittsburgh, PA, June 22-25, 2008.