

May 2008

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Recommended Citation

Riddle, Emma Jane and Smith, Marilyn (2008) "Developing and Using Rubrics in Quantitative Business Courses," *The Coastal Business Journal*: Vol. 7 : No. 1 , Article 7.

Available at: <https://digitalcommons.coastal.edu/cbj/vol7/iss1/7>

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DEVELOPING AND USING RUBRICS IN QUANTITATIVE BUSINESS COURSES

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ABSTRACT

A rubric is a set of guidelines for assessing student performance. Rubrics have several important uses in the classroom, in program evaluation, and in accreditation review. A process for rubric development and examples of four types of rubrics are given. The best type of rubric for a quantitative task depends on the nature of the task and the reason for using a rubric. The major contribution of this article is a table that helps faculty select a rubric type for quantitative problems and three types of case problems.

INTRODUCTION

Merriam-Webster Online defines a rubric as “an authoritative rule; an established rule, tradition, or custom” (Merriam-Webster, 2007-2008). When student performance is being evaluated, a rubric is a set of guidelines or instructions for assessing student performance, including expectations and evaluation criteria (Popham, 1997). Rubrics have a number of uses in the classroom. They are also used to assess student performance on program learning goals, which provides data for program evaluation and accreditation review.

In an effort to find rubrics for evaluating the performance of business students on quantitative tasks, the authors of this article searched Business Source Premier, Academic OneFile, and Academic Search Premier. Examples of rubrics for quantitative tasks were almost non-existent. The authors did a Google search of online resources and also checked three Web sites which are known for their links to a variety of rubrics. The AACSB Web site (AACSB International, n. d.) did not include links to rubrics for quantitative tasks. The Winona State University site (Winona State University, 2006) provided links to rubrics for problem-solving and quantitative reasoning; the Portland State University site (Portland State University, 2008) included links to mathematics rubrics. Very few of the rubrics found were designed for university-level courses. The search for rubrics also revealed that several types of rubrics are commonly used, but the literature gives little guidance about when to use each type.

The goal of this article is to provide examples and guidance for business faculty who want to use rubrics to assess students' performance on quantitative reasoning tasks, including problem solving and case problems. First, the literature related to developing and using rubrics in business courses will be reviewed. Next, the development and use of rubrics for quantitative problem solving will be discussed, and an example of the use of a rubric for assessment will be given. Then the development and use of rubrics for case problems will be described. Finally, recommendations for selecting rubrics for various uses will be made.

REVIEW OF LITERATURE

This review will be divided into four sections: (1) rubrics in the classroom, (2) using rubrics for program evaluation and accreditation review, (3) types of rubrics, (4) developing rubrics for quantitative business courses.

Rubrics in the Classroom

A good rubric provides specific performance expectations to students and a clear grading guide for the teacher (Stevens & Levi, 2005). When an assignment is made, a well-designed rubric helps students understand what the learning objectives are and how their work will be evaluated (Andrade, 2005). Students can also use a rubric for self-assessment, which allows them to think about the quality of their work and improve their performance (Anglin, Anglin, Schumann, & Kaliski, 2008; Anderson, 1998). Since expectations are clearly defined, grading is likely to be more objective and consistent (Anglin et al., 2008; Nitko, 2004). This is an advantage in individual sections and in multi-section courses that are taught by several instructors.

For teachers, using a rubric for grading reduces the time required to give students feedback about their strengths and weaknesses (Anglin et al., 2008; Andrade, 2005; Stevens & Levi, 2005); that type of feedback can improve learning (Black & Wiliam, 1998) and help students understand their grades (Stevens & Levi, 2005). Taylor (2007) found that teaching assistants who graded with a rubric gave less directive feedback and made more comments that encouraged students to think critically. For teachers, a rubric also makes it easy to tabulate the types of mistakes that students are making, so that the teacher can see which concepts need to be reviewed with the students (Stevens & Levi, 2005).

Using Rubrics for Program Evaluation and Accreditation Review

Both program evaluation and accreditation reviews involve assessment of student performance. The following description of the assessment process is based on the work of Suskie (2004) and Palomba and Banta (1999), and on AACSB Assurance of Learning Standards (AACSB, 2007, Standards 15 – 21).

1. Set learning goals for the academic program. Learning goals usually cover broad areas, such as communication skills, critical thinking, quantitative reasoning, and ethical reasoning.
2. Determine which learning goals should be taught in each course. In AACSB-accredited programs, the same learning goal is often addressed in several courses.
3. Develop measurable learning outcomes for each learning goal. For instance, what competencies should a student have in quantitative reasoning?
4. Develop metrics to measure student performance on each outcome. In quantitative courses, measurement may be done by using a rubric to evaluate students' skills in solving problems covered in the course. The metrics should be detailed enough to provide the data needed for assessing curriculum, course content, and teaching

strategies. The process of developing a rubric encourages faculty to communicate about expectations and performance standards, which may make instruction more consistent.

5. Use the metrics to collect data about student learning.
6. Analyze the data and draw conclusions. What are the students doing well, and where are they having problems? Have they been given sufficient opportunities to master the learning objectives? Should changes be made in the curriculum or in the content of individual courses? Are new teaching strategies needed in some courses? This evaluation gives faculty, including adjunct faculty, the opportunity to learn from each other.
7. Implement the changes developed in step 5.

The first four steps in this process focus on planning and developing an assessment program; the learning goals, outcomes, and metrics developed in these steps should be revised periodically. The last three steps in the process are ongoing activities that support continuous program improvement and increased student learning.

When several faculty members teach the same course, data collected for program review and accreditation review should be consistent across instructors (interrater reliability). Several suggestions for improving interrater reliability have been made in the literature. Palomba and Banta (1999) advocate detailed rubrics and training sessions for raters. According to Stevens and Levi (2005), interrater reliability may be higher if all faculty who teach the course are involved in developing the rubric. Nitko (2004) recommends the use of task-specific rubrics, rather than general-purpose rubrics. In a particular situation, the choice of either general-purpose or task-specific rubrics may depend on the number of tasks being assessed, the types of tasks being assessed, the amount of faculty time required to develop either one general rubric or several task-specific rubrics, and the experience of the raters.

Types of Rubrics

Several different kinds of rubrics are used for evaluating student performance. Four types – checklist, holistic, analytic, and hybrid – are most likely to be applicable to quantitative reasoning. These four types are defined below; examples of each type will be given later in this article.

- The simplest type of rubric is a checklist of evaluation criteria, based on points that have been taught or elements that should be included in each student's work. On each criterion, the student either receives credit or does not receive credit. There is no measure of overall performance.
- Like a grading system, a holistic rubric classifies student work by performance level. A holistic rubric provides a single description, addressing all criteria, for each performance level. A holistic rubric provides a general measure of overall performance. The performance levels can be equated to letter grades or to qualitative descriptions of performance, such as "meets expectations".
- An analytic rubric is a list of evaluation criteria, weighted by the number of points allocated to each criterion. An analytic rubric gives a numerical score, which can be

can be converted to a grade or performance standard. For instance, a score of 70% might be required for a "meets expectations" rating.

- There is more than one type of hybrid rubric. The hybrid rubric that is of interest in quantitative courses combines an analytic rubric with a holistic rubric.

Developing Rubrics for Quantitative Business Courses

A process for developing rubrics is given below. The process may seem complex, but some steps will take very little time.

1. Define the performance task on which students will be assessed.
2. Determine the purposes for which the rubric will be used. Is it primarily for classroom use, or will it be used for program evaluation or accreditation review? If the rubric will be used in the classroom, how will it be used?
3. Decide whether to use a general-purpose or a task-specific rubric.
4. Decide whether to use a checklist, a holistic rubric, or an analytic rubric. This issue will be discussed in the next section.
5. Look for models or templates that meet your needs, or could be adapted to your needs (Suskie, 2004). A general-purpose rubric can often be used as a framework for a task-specific rubric (Nitko, 2004).
6. If you need to develop or adapt a rubric, list the evaluation criteria that should be included or added (Stevens & Levi, 2005). These will often be based on grading criteria that you have used in the past, and on mistakes that students often make.
7. Arrange the criteria in a logical order, and group related criteria. This makes the rubric easier for students to understand and easier for teachers to use.
8. For a checklist rubric, put the criteria into a checklist format. For an analytic rubric, put the criteria into a table format, and allocate points to each criterion; the allocation can often be based on what you have done in the past. For a holistic rubric, decide how many performance levels to use and write a description of each one. Suskie (2004) suggests that three to five performance levels should be included; more than five levels may make it hard for raters to distinguish between levels. The top level of performance should be defined by describing exemplary work (Stevens & Levi, 2005). Although you are describing the student's finished product as a whole, the description should relate the work to each criterion. After defining the top level, define the bottom level of performance; then fill in the intermediate levels (Stevens & Levi, 2005).
9. Test a new holistic, analytic, or hybrid rubric against actual or hypothetical student work. Are the grades or performance evaluations reasonable? Can you distinguish among various levels of performance?
10. After you have used the rubric for its intended purpose, evaluate it and make changes if necessary.

There are a few model rubrics which faculty in quantitative business courses can adapt for their needs. An excellent general, holistic rubric for problem solving was developed by the Schreyer Institute for Teaching Excellence (2007). In evaluating student work, this rubric considers four factors: the mathematical concepts used by the student; the computations or

procedures selected to solve the problem; recognizing constraints in the problem situation; and the correctness of the computations and solution. This rubric would be appropriate for most quantitative courses in business. Marsh (1998) developed a holistic rubric for statistical investigations. Marsh's rubric considers three factors: methodology, data analysis, and conclusions. This rubric might be a useful starting point for faculty who teach business statistics or market research and require a research project based on primary data.

DEVELOPING AND USING RUBRICS FOR QUANTITATIVE PROBLEMS

In the literature review, six uses for rubrics were identified: communicating expectations to students, student self-assessment, grading, giving feedback to students, assessing student performance, and encouraging communication among faculty. In this section, three rubrics for linear programming (LP) will be presented, and the process of developing them will be discussed. These rubrics are consistent with each other; taken together, they cover all six purposes mentioned above. These rubrics have been used for several purposes; aspects of this experience that might be helpful to other business faculty will be discussed.

Although the examples in this section focus on linear programming, a similar approach could be used for other types of quantitative problems, such as breakeven analysis, computing and interpreting financial ratios, forecasting sales, and testing statistical hypotheses. The rubrics presented here are samples, not models; they would require modifications for other types of problems, and for differences in program goals, learning objectives, teacher expectations, grading preferences, and the level of detail desired.

An Analytic Rubric for an Assessment Task

At the authors' university, one of the learning goals for the BSBA and MBA programs is: "Students will be able to demonstrate rational decision making using quantitative tools, strategies, and data". This goal is assessed in several courses, using both multiple choice tests and quantitative tasks in each course. The authors were asked to develop a task and a rubric for assessing this goal in the undergraduate and graduate operations management courses; the assessment results would be used for program evaluation and for enhancing communication among faculty members, including adjunct faculty. The assessment task requires students to formulate an LP model in standard form. Faculty teaching an operations management course are required to include this task in one of the tests given in the course. Since previous tests often circulate among students, the definition of the task does not specify a particular problem. Instead, the characteristics of the problem, such as the number of variables and the types of constraints, are specified. Problems used to assess MBA student performance have more variables, more constraints, and more complex constraints than problems used to assess undergraduates.

Since an analytic rubric considers all evaluation criteria individually and also weights the criteria by importance, it gives a more precise score than other types of rubrics. Therefore, analytic rubrics are probably the best choice for performance assessment, grading test questions, and grading complex quantitative assignments. For a quantitative problem, analytic rubrics also give more exact feedback to students than the other types of rubrics.

To develop the LP assessment rubric, the authors began by listing the criteria for a correct solution. To encourage consistent grading, there were six grading criteria for constraints. The authors decided to use a 20-point grading scale and allocated the points among the criteria. The rubric is shown in Table 1.

Table 1: Example Analytic Rubric for Linear Programming Model Formulation

	Points
The decision variables are defined correctly.	2
The formula for the objective function is correct. Either maximization or minimization is correctly specified.	3
All constraints listed in the problem are included.	3
The non-negativity constraints are included.	1
All constraints are written in standard form, with formulas or variables on the left side, and constants on the right.	2
The formulas in the constraints are correct.	6
The \leq , $=$, and \geq signs in the constraints agree with the wording of the problem.	2
The right-hand sides of the constraints are correct.	1

This rubric has now been used to collect assessment data for three semesters. It is efficient to use the rubric for grading the test question, as well as for assessment. For grading criteria that are worth more than one point, partial credit is allowed. After the tests have been graded, each student's score on each criterion is entered into a spreadsheet, along with the student's total score; average scores are computed for each section, and for all students in all sections. All this information is reported for assessment purposes. Faculty teaching the course discuss this data after each semester; we have identified a few areas where some students have trouble and are modifying our instruction accordingly. With three semesters of data, we can begin to use the assessment data to monitor trends.

An Analytic Rubric for Grading and Giving Feedback to Students

The assessment rubric was expanded so that it could be used for grading an LP assignment. The assignment requires students to formulate the problem in standard form, set the problem up in Excel and Excel Solver, solve the problem, and interpret the results. The expanded rubric has three sections: model formulation, using Excel and Excel Solver, and interpreting the results. A 50-point grading scale is used; 20 points are allocated to model formulation, 20 to using Excel and Excel Solver, and 10 to interpretation of results. The grading rubric is shown in Table 2. The model formulation section is identical with the assessment rubric; this sets consistent standards for students. After using the assessment rubric in Table 1, the authors believe that the rubric in Table 2 will work well for grading and will provide an efficient way of helping students identify their errors. It is likely that additional feedback will be needed to help students correct their errors.

TABLE 2: Example Analytic Rubric for Linear Programming Assignment

	Points
MODEL FORMULATION – 20 points	
The decision variables are defined correctly.	2
The formula for the objective function is correct. Either maximization or minimization is correctly specified.	3
All constraints listed in the problem are included.	3
The non-negativity constraints are included.	1
All constraints are written in standard form, with formulas or variables on the left side, and constants on the right.	2
The formulas in the constraints are correct.	6
The \leq , $=$, and \geq signs in the constraints agree with the wording of the problem.	2
The right-hand sides of the constraints are correct.	1
EXCEL AND SOLVER – 20 points	
The spreadsheet is organized in a logical way.	2
The rows and columns in the spreadsheet are labeled appropriately.	2
The coefficients and right-hand sides in the spreadsheet are correct.	4
The formulas for the objective function and resource utilization are correct.	4
The target cell, adjustable cells, and constraints are specified correctly in Solver.	4
The final spreadsheet includes a correct Solver solution.	4
INTERPRETATION OF RESULTS – 10 points	
The results for the objective function and decision variables are correctly stated. The implications for business are explained correctly.	6
Questions related to slack and surplus are correctly answered.	4

A Checklist Rubric for Communicating Expectations and Student Self-Assessment

Checklist rubrics are often used to communicate expectations to students and as a tool for students to make a preliminary check of their own work. Usually, the students check to see that all required elements of the solution are present. They may also check formatting or other aspects of their work that are easy to evaluate. Since many students will not be able to check the correctness of their work, most checklist rubrics do not include correctness as a criterion. Therefore, the requirements in a checklist rubric are usually weaker than those in a grading rubric.

To construct the sample checklist rubric, the grading criteria in Table 2 were reviewed. Thirteen of the sixteen criteria either did not require correctness, or could be re-stated in a form that did not require correctness. Those thirteen criteria are included in the sample rubric, which is shown in Table 3. Three criteria related to constraints could not be re-stated in a way that did not require correctness, and those criteria were omitted from the rubric in Table 3. Since a checklist rubric is based on simple modifications of grading criteria, it is the easiest type of rubric to design.

One of the authors posted this rubric online, so that students could refer to the rubric as they worked on the LP assignment. While the data gathered is limited and anecdotal, students

apparently completed the formulation stage of the assignment more quickly and with fewer errors than in the past.

TABLE 3: Example Checklist Rubric for the Linear Programming Assignment

	Meets	Does Not Meet
PROBLEM FORMULATION		
The decision variables are defined.		
There is a formula for the objective function. Either maximization or minimization is specified.		
All constraints mentioned in the problem are included.		
The non-negativity constraints are included.		
All constraints are written in standard form, with formulas or variables on the left side, and constants on the right.		
EXCEL AND SOLVER		
The spreadsheet is organized in a logical way.		
The rows and columns in the spreadsheet are labeled appropriately.		
The coefficients and right-hand sides are shown in the spreadsheet.		
The formulas for the objective function and resource utilization are shown in the spreadsheet.		
The target cell, adjustable cells, and constraints are specified in Solver.		
The final spreadsheet includes a Solver solution.		
INTERPRETATION OF RESULTS		
The results for the objective function and decision variables are stated. The implications for business are explained.		
Questions related to slack and surplus have been answered.		

Summary

The best rubric to use for a quantitative problem depends on the purpose for which the rubric will be used. Analytic rubrics are recommended for assessment, communicating expectations among faculty, grading, and giving feedback to students. Checklist rubrics are preferred for communicating expectations to students and for student self-assessment. Rubrics for all these uses should have consistent grading criteria; this helps to set consistent performance standards for students and uses faculty time efficiently.

DEVELOPING AND USING RUBRICS FOR CASE PROBLEMS

Types of case problems

Textbooks used in quantitative business courses include three types of case problems:

- Type 1 case problems are extended quantitative problems that are set in a business context and are more complex than the short problems at the end of a chapter. The case questions require a straightforward interpretation of computational results. The Spring Garden Tools case (Russell & Taylor, 2009, Case Problem S14.3) is an example of this type. Students are required to use linear programming to develop an aggregate

production plan. The case question requires an understanding of binding and non-binding constraints.

- Type 2 case problems are set in a business context and require students to apply mathematical models or analytic tools, such as flowcharts. The case questions are open ended and often require students to develop recommendations for solving a business problem or taking advantage of a business opportunity. The Tech Bookstores case (Russell & Taylor, 2009, Case Problem 2.3) is an example of this type. Students are required to use a Pareto analysis and qualitative information in the case to develop recommendations for improving service quality at two bookstores owned by a university.
- Type 3 case problems describe a business problem or opportunity but do not provide the type of data needed to use mathematical models or analytic tools. The case questions are open ended and usually require students to develop recommendations for solving a business problem or taking advantage of a business opportunity. The D4Q case is (Russell & Taylor, 2009, Case 2.1) is an example of this type of case. Students are required to recommend a quality management system for a new e-commerce shopping site.

Since Type 1 case problems are so similar to the quantitative problems discussed in the last section, the rubric types recommended for quantitative problems are also appropriate for Type 1 case problems. In the remainder of this section, recommendations will be made for developing rubrics for Type 2 and Type 3 case problems. Rubrics for grading and giving feedback to students will be discussed first; then rubrics for other uses will be discussed.

Rubrics for Grading and Giving Feedback for Type 2 and Type 3 Case Problems

This section will describe a rubric the development, use, and revision of a rubric for the Tech Bookstores case (Russell & Taylor, 2009, Case Problem 2.3) in a graduate operations management class. The revised rubric will be presented. Then general recommendations will be made for rubric types to be used for grading and giving feedback for Type 2 and Type 3 case problems.

In the Tech Bookstores case, the bookstore manager has received several complaints about service quality from faculty and non-student customers. The case includes data from a customer quality survey; the data is classified by bookstore location and type of customer. The textbook case instructed students to use Pareto analysis of the survey data to prioritize the quality problems at the bookstores and make recommendations for improving service quality. The authors added a cause-and-effect diagram to the assignment; the diagram provides an organized way to list possible causes of a quality problem (effect) and identify the most likely causes. Instead of just making recommendations, students were required to write a technical report that explained the results of their analysis and included recommendations, with a justification for them.

Initially, an analytic rubric was developed for this case. To communicate expectations and the grading system, the rubric was given to students along with the assignment. Some performance issues that had been problems in the past did not occur when the rubric was used,

which suggests that most expectations were communicated effectively. When the assignment was graded, students received a copy of the scored rubric, along with comments as needed; this feedback strategy was suggested by Stevens and Levi (2005). Although the sample was small, anecdotal evidence suggests that students were satisfied with the feedback they received; there were very few questions and no complaints from students about grades.

From the teacher's viewpoint, the analytic rubric worked well for grading the Pareto chart and the cause-and-effect diagram, but using it for the technical report caused concern. Assigning points separately for each grading criterion made it hard to evaluate the overall quality of the report. It was often necessary to compare a student's rubric score with the grade that would have been assigned if the report had been evaluated in a holistic way.

The analytic rubric was re-designed as a hybrid rubric, which is shown in Table 4. The analytic format was retained for the Pareto analysis and the cause-and-effect diagram; a holistic format was used for the technical report. Fourteen points were allocated to the Pareto analysis, 36 to the cause-and-effect diagram, and 50 to the technical report. The rubric for the technical report has four levels of performance, which correspond to the letter grades that are typically used in graduate courses. From previous experience, the authors knew that students with limited business experience sometimes have trouble developing appropriate recommendations. Consequently, several criteria are designed to guide students toward better recommendations, while still requiring them to think critically about the case.

Table 4: Revised Rubric for the Tech Bookstores Case

Part I: Analysis (50 points)

		Maximum Points	Your Points
Pareto chart	Defects are identified correctly.	5	
	Percentages are calculated correctly.	5	
	The information in the chart is formatted as described in the assignment. The chart is large enough to read easily.	4	
	Total points for Pareto chart	14	
Cause-and-effect diagram	The information and data in the case were used to develop a reasonably complete list of possible causes. The listed causes are relevant to the problem (effect). The diagram shows that the team "asked why" to find possible sub-causes.	20	
	The possible causes were categorized correctly.	6	
	The diagram is in the correct format, with the causes and the effect clearly shown. Relationships among causes are clear. The diagram is well-organized and easy to read.	10	
	Total points for cause-and-effect diagram.	36	

Table 4 (continued): Revised Rubric for the Tech Bookstores Case

Part II: Technical Report (50 points)

A	The description of the quality problem is accurate, complete, and detailed enough for the reader to understand the case. The findings in the Pareto chart are described accurately. The list of principal causes of the problem is complete, and consistent with the cause-and-effect diagram and other information in the case. If the listed principal causes are eliminated, the problem will be solved, or almost entirely solved. The recommendations focus on the problem and address all principal causes that were identified in the analysis. Implementing the recommendations would solve the problem, or almost all of the problem. The recommendations are consistent with any constraints in the case. The report is well-organized and well-written. There are few, if any, errors in sentence structure, grammar, spelling, or punctuation.
B	The description of the quality problem is accurate and complete, or has one or two minor errors or omissions. The description is detailed enough for the reader to understand the case. The findings in the Pareto chart are described accurately. The list of principal causes of the problem is consistent with the cause-and-effect diagram and other information in the case, but one or two principal causes may be omitted. If the listed principal causes are eliminated, most of the problem will be solved. The recommendations generally focus on the problem and address most of the principal causes that were identified in the analysis. Implementing the recommendations would solve most of the problem. There may be one significant error, such as a recommendation that is not related to the problem, or is not consistent with the constraints in the case. The report is well-organized and fairly well-written. There may be a few errors in sentence structure, grammar, spelling, or punctuation.
C	The description of the quality problem has several significant errors or omissions. The description may not be detailed enough for the reader to understand the case. The findings in the Pareto chart may not be described accurately. The list of principal causes of the problem may not be consistent with the cause-and-effect diagram and other information in the case, or several principal causes may be omitted. If the listed principal causes are eliminated, some of the problem will be solved. Some recommendations focus on the problem, but others may be irrelevant. Some principal causes are addressed, but several are ignored. Implementing the recommendations would solve some of the problem. There may be several significant errors, such as recommendations that are not related to the problem, or are not consistent with the constraints in the case. The report may be poorly organized and poorly written. There may be numerous errors in sentence structure, grammar, spelling, or punctuation.
F	The description of the quality problem is missing or does little to help the reader understand the case. The description of the Pareto chart is missing, or it contains several errors. The list of principal causes is missing, or it omits most principal causes in the case. Eliminating the listed principal causes will not contribute much to solving the problem. There are no recommendations, or implementing the recommendations would do little to solve the problem. There may be several significant errors, such as recommendations that are not related to the problem, or are not consistent with the constraints in the case. The report is poorly organized and poorly written. There may be numerous errors in sentence structure, grammar, spelling, or punctuation.

The authors' recommendations for Type 2 and Type 3 case problems are based on this experience with the Tech Bookstores case, which we believe is representative of Type 2 case problems. The common elements of Type 2 case problems are (1) the use of mathematical models and/or analytic tools, and (2) a requirement to answer open-ended questions, which often include making recommendations. For grading these cases and giving feedback to students, the authors recommend hybrid rubrics, consisting of an analytic rubric for the mathematical modeling and analytic tools, and a holistic rubric for the open-ended questions. For Type 3 case problems, where all questions are open ended, holistic rubrics are recommended for grading and giving feedback.

Other Uses of Rubrics for Type 2 and Type 3 Case Problems

Assessment requires a rubric that gives a precise performance measure on each segment of the task. Since analytic rubrics give the most precise scores for each part of a task, they are recommended for assessment and for communication among faculty. If there is an existing hybrid or holistic rubric, it can be used as a basis for the analytic rubric. The Tech Bookstores

rubric will be used as an example of this process. The analytic portion of the hybrid rubric can be included in the assessment rubric without any changes. Grading criteria for the technical report can be determined from the top performance level of the holistic part of the hybrid rubric. The top performance level for Tech Bookstores includes nine statements, and they are distinct enough to be evaluated separately. Each of these statements should become a grading criterion in the assessment rubric, and the 50 points allocated to the technical report should be divided among those nine criteria. Similarly, if there is an existing holistic rubric for a Type 3 case problem, grading criteria should be based on the top performance level, and points should be allocated among those criteria.

As stated in the section on quantitative problems, checklist rubrics are the recommended method for communicating expectations and for student self-assessment. However, some faculty may want to communicate expectations to students and explain the grading system for a case problem at the same time; this can be done by giving the grading rubric to the students along with the assignment.

Summary

Three types of case problems have been defined. For all types of case problems, analytic rubrics provide the best data for assessment and communication among faculty; checklist rubrics are preferred for communicating expectations to students and student self-assessment. For Type 1 case problems, analytic rubrics are recommended for grading and giving feedback to students. For Type 2 case problems, hybrid rubrics are recommended for grading and feedback; for Type 3 case problems, holistic rubrics are recommended for those purposes.

CONCLUSIONS

Rubrics have a number of important uses, including communicating expectations to students, student self-assessment, grading, giving feedback to students, assessing student performance, and encouraging communication among faculty. This paper has explored the use of rubrics for quantitative problems and for three types of case problems. Four types of rubrics were recommended for use with various types of quantitative and case problems; the four rubric types are checklist, analytic, holistic, and hybrid. An example of rubric development was given for each of the four types. When two or more rubrics are used for the same quantitative task, the grading criteria should be consistent across rubrics; this sets consistent performance standards for students and uses faculty time efficiently. Methods for achieving consistency were presented.

The most important contribution of this paper is the synthesis of recommendations found in the literature and the authors' experiences to suggest which type of rubric is best suited for a particular use. The best rubric to use for a quantitative task depends on the reason for using the rubric and the nature of the task, as discussed in previous sections and summarized in Table 5.

- Checklist rubrics are preferred for communicating expectations to students and for student self-assessment.
- Analytic rubrics are recommended for assessment and communication among faculty.

- For quantitative problems and Type 1 case problems, analytic rubrics are recommended for grading and giving feedback to students.
- For Type 2 case problems, hybrid rubrics are suggested for grading and giving feedback to students.
- For Type 3 case problems, holistic rubrics are recommended for grading and giving feedback to students.

Table 5: Selecting a Rubric Type

Purpose of Rubric	Computational Problems	Type 1 Case Problems	Type 2 Case Problems	Type 3 Case Problems
Communicate expectations to students	Checklist	Checklist	Checklist	Checklist
Student self-assessment	Checklist	Checklist	Checklist	Checklist
Grade student work	Analytic	Analytic	Hybrid	Holistic
Give feedback to students	Analytic	Analytic	Hybrid	Holistic
Assess learning outcomes	Analytic	Analytic	Analytic	Analytic
Communication among faculty	Analytic	Analytic	Analytic	Analytic

A process for rubric development has been presented. A new analytic, holistic, or hybrid rubric should be tested against actual or hypothetical student work before being used. After the rubric has been used for its intended purpose, it should be evaluated and revised if necessary.

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ACKNOWLEDGMENT

The authors wish to acknowledge the contribution of Dr. Susan K. Green, Professor of Education at Winthrop University, to the development of Table 5.