Rubrics Cubed: Tying Grades to Assessment to Reduce Faculty Workloads

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I. Background

Assessment of program outcomes is an important, but time-consuming, part of the ABET accreditation process for faculty. Many faculty members argue, "I grade; therefore, I assess." The problem with using grades as assessment tools is that grades often cover material that represents more than one programmatic outcome.[1, 2] In addition, there may be a great deal of variability in assignment of grades, depending on which faculty member does the grading. The purpose of this paper is to demonstrate that rubrics offer an excellent method for reducing faculty workload by providing a means to link grading and assessment.[3]

Faculty members of the Biomedical Engineering (BME) Courses and Curriculum Committee, which is also responsible for assessment, have worked as a team to develop several rubrics that are used by individual faculty to grade projects or other samples of student work in several BME courses. Different components of the rubrics can then be employed in various combinations to assess various programmatic outcomes. Each rubric is designed to result in the same grade and/or assessment evaluation independent of the faculty member who is doing the grading and/or assessing.

Our program has numbered objectives (1, 2, 3, 4), with alphabetically-labeled outcomes (a, b, c …). In the example below, the numbering scheme results from the fact that we are assessing our coverage of only three outcomes (1.c, 2.b, and 2.c) selected from our entire set of 15.

II. Combining assessment and grading

Students in BAE 381 (Human Physiology for Engineers) use Simulink® to reproduce mathematical models of a physiological system. The models that are reproduced are ones that have been published in peer-reviewed journals.[4] These projects, which are completed in teams of 3-4 students and represent 15% of the course grade for each student, are used to assess three of our BME program's outcomes. The BME objectives and outcomes addressed by the project with corresponding ABET 3a-3k outcomes in parentheses are:

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1. To educate students to be successful in Biomedical Engineering by emphasizing engineering and biology as related to basic medical sciences and human health.
   After completing the B. S. in Biomedical Engineering, graduates will be able to:
   c. Design and model biomedical materials, systems, and/or devices. (3a, 3c, 3e, 3k)
2. To produce Biomedical Engineers able to communicate effectively with diverse audiences and prepared to work in multidisciplinary teams.
   After completing the B. S. in Biomedical Engineering, graduates will be able to:
   b. Prepare effective written materials. (3g)
   c. Use modern engineering tools to communicate ideas with others within the engineering discipline. (3g)

A rubric is used to grade the projects and provide assessment data. Table 1 shows the categories in the rubric that are combined to assess BME program outcome 1.c. Table 2 shows the categories in the rubric that are combined to assess BME program outcome 2.b. Table 3 shows the category in the rubric that is used to assess BME program outcome 2.c. Each of these seven categories has a weighting factor of 2.5 for grading purposes. For example, projects that are rated as exemplary in all seven categories receive 70 points (7 categories x weighting factor of 2.5 x value of 4 for exemplary), and projects that are rated as beginning in all seven categories receive 17.5 points. There are ten categories in the full rubric, with each category having a weighting factor of 2.5. Thus, some of the categories that are used for grading the project are not used for assessing outcomes.

Table 1: Assessment Categories for BME Outcome 1.c

Category	4 Exemplary	3 Satisfactory	2 Developing	1 Beginning
Documentation of what the Simulink® model does	Printouts of the important graphs or other data are included. The graphs or data are labeled, and their importance is explained. The documentation states if the graphs or data differ from the expected output of the paper.	Graphs or data are properly labeled, but the documentation does not explain the importance of them. The documentation states if the graphs or data differ from the expected output of the paper and if they will change upon completion of the model.	Graphs or data are included, but their meaning is not explained. No mention is made of whether or not the graphs or data are the same as or different from the expected output.	No graphs or data are included. Only written confirmation is given as to whether or not the program does what it is supposed to do.
Final status of the Simulink® model	The documentation explains what does work and what does not work (if anything) and gives reasons as to why each incorrect part is not working. The documentation explains what the team has done to fix any problems they still have. The documentation suggests other things that they could do to fix any remaining problems.	The documentation explains what works and what does not work and gives reasons why some parts are not working. The documentation explains what the team has done to try to fix the problems, explains how their attempts worked out.	The documentation explains what works and what does not work but does not give reasons why it may not be working. The documentation describes what they have done to try to fix the problems.	The documentation states that the model does not work but does not explain what parts of the model work or do not work and does not specify what kinds of things they have tried to fix the model.

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Table 2: Assessment Categories for BME Outcome 2.b

Category	Exemplary – 4	Satisfactory – 3	Developing – 2	Beginning – 1
Summary of the design of the original article	The summary begins with an introduction that describes the physiology and/or pathophysiology in terms that could be easily understood by a layperson. The physiology presented in the model and why this particular physiological model is important are discussed in well-written, paragraph form. The discussion explains how the model represents normal physiology or pathophysiology and how it helps further understanding of how the human body functions. The equations are explained so that someone who has not read the paper would understand the model.	The summary is not written in a form that could be easily understood by a layperson. Either the physiology or why the physiological model is important is discussed in well-written, paragraph form. The discussion explains how the model represents normal physiology or pathophysiology or how it helps further understanding of how the human body functions. Most of the equations are explained.	The summary is not written in a form that could be easily understood by a layperson. Either the physiology or why the physiological model is important is discussed in well-written form. The discussion attempts to explain how the model represents normal physiology or pathophysiology or how it helps further understanding of how the human body functions. Some of the equations are explained.	The summary is not written in a form that could be easily understood by a layperson. Either the physiology or why the physiological model is important is discussed in paragraph form. A very limited attempt is made to explain how the model represents normal physiology or pathophysiology or how it helps further understanding of how the human body functions. No equations are explained
Authors' assumptions and conclusions	The authors' assumptions and conclusions are clearly stated. How the authors developed their model using experimental data and the limitations of the final model are clearly discussed.	Most of the assumptions and conclusions are clearly stated. How the authors developed their model using experimental data and the limitations of the final model are clearly discussed.	Several of the assumptions and conclusions are clearly stated. How the authors developed their model using experimental data and the limitations of the final model are mentioned.	Few of the assumptions and conclusions are clearly stated. How the authors developed their model using experimental data and the limitations of the final model are discussed poorly.
Written description of the Simulink® model	The documentation explains how the model is organized (in subsystems or colors), explains why the team chose the organizational method that they used, and states what kind of functions were used, including any special functions the team had to use for special variables (like RAMP functions, or any functions that they had to teach themselves how to use) or if they used only the functions that they already knew how to use. Equations are explained so that someone unfamiliar with the original model would understand it based on the SIMULINK model.	The documentation explains how the model is organized (in subsystems or colors) but not why they used the organizational method that they did. The documentation explains what kind of functions they used and if any of those functions were functions that they did not know how to use already.	The documentation explains how the model is organized but does not go into detail as to what kind of functions were used or if any functions were used that they did not already know how to use.	The documentation does not explain how they organized their model, but may mention some of the functions that they used.
Spelling and grammar	There were no more than two spelling or grammar errors.	There were no more than four spelling or grammar errors.	There were no more than six spelling or grammar errors.	There were no more than eight spelling or grammar errors.

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Table 3: Assessment Category for BME Outcome 2.c

Category	4 Exemplary	3 Satisfactory	2 Developing	1 Beginning
Organization of the Simulink® model	There is a block diagram that gives a complete overview of the Simulink model. Colors and subsystems are used to differentiate between the different equations. All of the blocks are appropriately labeled or the labels are hidden. Appropriate lines are labeled as well. All of the variables are defined. Comments are added to completely explain equations and how the program flows.	There is a block diagram that gives an adequate overview of the Simulink model. Colors or subsystems are used to differentiate between the different equations. Some blocks are not labeled or the labels are not hidden, and/or some lines are not labeled that should have been labeled. Many comments are added to explain equations and how the program flows.	There is a block diagram that gives a partial overview of the Simulink model. Colors or subsystems are used to differentiate between the different equations. Several blocks are not labeled or the labels are not hidden, and/or several lines are not labeled that should have been labeled or are not labeled correctly. Some comments are added to explain equations and how the program flows.	There is no block diagram to describe the Simulink model. Equations are not organized into subsystems or colors. Many blocks are not labeled or the labels are not hidden, and/or many lines are not labeled that should have been labeled or are not labeled correctly. Few comments are added to explain equations and how the program flows.

III. Assessment of projects

In the fall of 2003, a team of three faculty members in the department met for over an hour to review the 2002 BAE 381 Simulink® projects. They used the grading rubric originally developed by the course instructor to evaluate each project. The review team concluded that the instructor's rubric was appropriate but could be improved and recommended several suggestions for the instructor, including changes in the instructions students that received and changes in the rubric itself that should result in better documentation of the projects. The results from this meeting were used in the 2002-2003 cycle for assessing BME program outcomes.

The category scores and overall project grades for the nine projects that were completed in BAE 381 in fall 2003 are shown in Table 4. The performance goal for meeting an outcome was that all projects will at least meet the criteria for satisfactory in each category. Thus, the data from these projects indicate that outcome 1.c was met but outcomes 2.b and 2.c were not. Since all of these outcomes are also assessed by other methods, e.g. examples of student work from other courses, failing to meet an outcome based on the BAE 381 project assessments does not mean that the outcome has not been met in the overall program. However, failing to meet an outcome at any stage of the assessment process does provide information about where improvements are needed in the program. For example, the reason that outcome 2.b was not achieved was that three teams failed to meet competency in the spelling and grammar category, something many engineering students need to improve, since all teams were competent in the other three categories. Outcome 2.c was not met because one team failed to define variables on each printed page of their Simulink® model printouts – they thought that it was sufficient to define variables on the block diagram in spite of what were thought by the instructor to be adequate instructions to the contrary.

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Table 4: Assessment Results for Fall 2003 BAE 381 Projects

	1.c		2.b				2.c	
Team	Documentation	Final Status	Summary of original model	Authors' assumptions and conclusions	Description of Simulink model	Spelling and grammar	Organization	Project Grade
1	4	4	4	4	4	4	3	97.5
2	4	4	3	4	4	1	3	85
3	4	4	4	4	4	3	3	95
4	4	4	4	4	4	3	4	97.5
5	4	4	4	4	4	4	4	100
6	4	4	3	4	4	4	4	92.5
7	4	4	4	4	4	2	2	90
8	4	4	4	4	4	0	3	87.5
9	4	4	3	4	4	4	3	95

IV. Reducing the assessment workload on faculty

Tying assessment to grading rubrics that are developed by faculty-led assessment committees greatly reduces the assessment workload on individual faculty since course instructors already have to grade assignments as part of their teaching functions. Using the BAE 381 project grading rubric to assess outcomes 1.c, 2.b, and 2.c added approximately 15 min to the instructor's grading time, i.e. less than an average single coffee break. Grading rubrics that relate course learning outcomes to program outcomes and are thoughtfully developed and modified by teams of faculty members make it more likely that program outcomes are being addressed in courses and make it easier for these same program outcomes to be assessed during the grading process.

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