Reconciling the Student's Deliverables with the Instructor's Expectations in Engineering Exams

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Introduction

The use of scoring rubrics for assessing student's task is becoming more common across universities in the US. Rubrics are scoring guides that states the criteria for evaluating a task and define the levels of quality of work and are used for evaluating student's assignments[1]. Rubrics may help focus both students and instructors on the most important elements of the assigned tasks. Rubrics may also help in reducing the subjectivity of conventional assessment techniques. Professors have used scoring rubrics for a student's written response to evaluate his/her understanding in subjects such as English, social studies, economics, law, natural and physical sciences[2-5]. The dissatisfaction among teachers and administrators with traditional grading strategies are believed to be the driving force for using rubrics for student's writing work [2]. Several reports indicate that rubrics make instructor's assessments more reliable [5, 6]. Predetermined expectations and criteria can promote learning by offering clear performance targets to students [7, 8].

On the other hand, the introduction of rubrics was also found to help in setting academic and teaching standards that may benefit industries. If rubrics are applied as a tool to measure the employability skills development and attainment of undergraduate students based on shared understanding by stakeholders benchmark standards, they can also provide a clear picture of what can realistically be achieved by a university graduate [9]. This may engage companies and universities in an ongoing dialogue on the expected skills and identifying areas of collaboration to enhance student learning.

In engineering education, scoring rubrics have been used in the performance evaluation of a wide range of ABET and other outcomes, including professional skills [10], ethics [11], writing skills [12], design competency [13, 14], and students' software skills [15]. The motivation to use scoring rubrics in engineering education also is due to the lack of satisfaction emanating from the use of the traditional grading process which have been criticized for their bias, and unrealistic standards [2, 9, 15]. Rubrics are attractive since they can be adjusted to assess specific skills and describe precisely the expected outcomes [16]. In addition, they can convey the professor's expectations to students, make the assessment method more transparent[17], and can facilitate in providing feedbacks to the students on the quality and quantity of student learning.

The use of rubrics in engineering education is mostly limited to design and writing projects/assignments. There are no reports of using rubrics for grading engineering exams. It is obvious that the use of rubrics in grading exams may be impractical. However, in engineering, exams often consist of solving problems or tasks that involve the application of a set of principles and laws with the help of mathematics. Unlike in multiple choice and true false type questions where a student is asked to choose from the list of available options, engineering exams require the student to submit his/her responses to the exam problem in written form. For example, when the response is a solution to a problem, it may involve multiple steps, sometimes assumptions, and may include relevant sketches. When grading such solutions, the instructor may give weights to both the thought process, the chosen assumptions, appropriate reasoning presented, the sketch, and the final answer. If no clear guidance is given, students may incorrectly assume the instructor's expectations and present solutions that are not in-line with what the instructor desires to assess. Since the submitted task doesn't have an answer key similar to a multiple choice or a true false question, the grading may involve some subjective judgments

about the elements the student included in the task or solution and the level of detail used by the student to solve the problem. This may significantly affect a student's grade. Although using scoring rubrics for exams may not seem feasible, defining guides that help students see the elements that the instructor emphasizes will reduce the subjective nature of the assessment process and may increase the reliability of the associated results. Therefore, the purpose of this study was to qualitatively examine how adding a simplified guide and grading criteria that clarifies the professor's expectation in exams benefit the test takers.

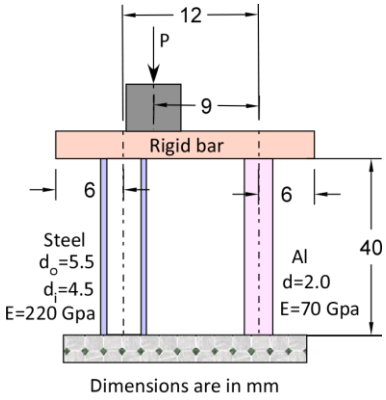
Methods

For this study, a guide that explains the instructor's expectations was provided in three engineering courses: Engineering Mechanics (Statics) (Course I), Computer Aided Engineering (Course II), and Machine Design (Course III). The numbers of students participated in Course I, Course II, and Course III are 15, 6, and 24, respectively. In our school, students take Course I during their sophomore year, Course II during junior year and Course III during their senior year. The guides consisted of detail elements that the instructor used to assess a student's solution along with the points assigned to the elements. Theses guides were presented next to each problem in both the midterm and the final exam. Figure 1 shows one of such guides that was provided next to one of the exam problems. The typical number of problems the students were asked to solve in both the mid and final exams were either three or four. Each of these problems have a similar guide. Prior to the exams or during the exams, students were not instructed to go through the guides. During the final exam, students were asked to respond to the following two open-ended questions, and their reflection on the questions were assessed.

1. Do you normally go through the guide and the grading criteria included next to each problem before attempting the problem?
2. Write the advantages and disadvantages of including such a guide and grading criteria for each problem.

The figure shows an aluminum and a steel rod that are fixed at the base and support a rigid structure. The diameters of the bars are given in the figure. If the yield strengths of the steel and aluminum rods are 295 Mpa and 240 Mpa, respectively,

a. Find the safe load P that should be applied on the rigid bar without yielding the two rods
b. Find the deformations caused on each rod due to the load found in part (a). Take modulus of elasticity for steel and aluminum as 220 Gpa and 70 Gpa, respectively.



No	Criteria	pts	Your score
1	Understanding the problem: givens, required, and clear plan	5	
2	Correct Free body diagram of the rods and rigid bar	10	
3	Correctly obtained forces in each rod	6	
4	Obtained the safe load correctly	10	
5	Determined the deformations in each rod correctly	10	
6	Solution has flow and neat, clear sketches	5	
	Total	46	

Figure 1. An example of a guide provided along with one of the exam problems in Course II

Results and Discussions

Although no instruction was given about the guide, most students paid attention to both the problem statements and the guides presented along with the problems. The percentages of students who responded "yes" to the first question in Course I, Course II, and Course III were 93.3%, 66.7%, and 87.5%, respectively. The low percentage in Course II is because there were only six students in the class. Some students included reasons why they chose to go through the guide and in which part of the exam time they did it. Some of these student responses are listed below:

1. Yes, I read through the instructions and grading criteria to understand the full problem
2. Yes, I do as it helps establish what I need to include and what I don't need to include
3. Yes, this helps me to break up my attack to the problem and try to earn the most points possible
4. Yes, I always do to ensure I am explaining and solving what is expected
5. Yes, it helps me know where most of the weight goes and needs more attention/work
6. Yes, I read through it to make sure I don't miss any potential points
7. I do so that I can attempt to get credit from all of them and not miss out on something simple
8. Yes, often help to ensure problem was properly understood
9. Yes, to see what I will be graded on to earn the most points
10. Yes, I do normally go through the grading criteria
11. I usually step out each problem and then check the grading criteria to make sure I didn't miss anything
12. Usually right after starting. Then go back and check that my process matches
13. Yes, I skim them before and read more carefully after

For the second question, students stated various benefits of having a guide and grading criteria on the exam. We have grouped their responses into five categories: clarify the professor's expectation, helps to maximize grade, helps student stay organized, facilitates feedback, and enhances student's confidence in attempting the exam. Figure 2 shows the number of times these advantages were mentioned by students in the three courses.

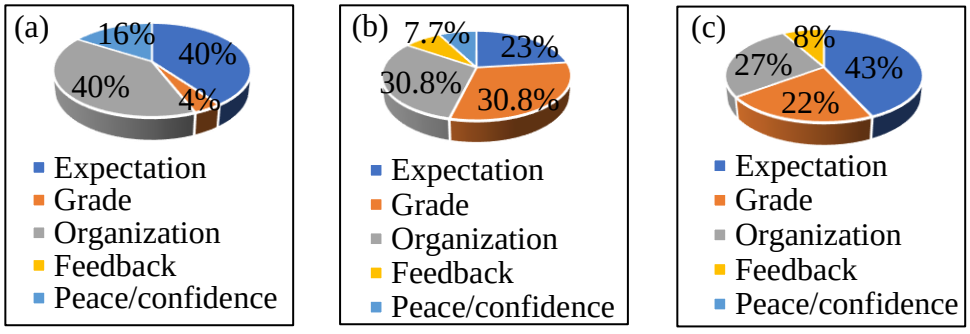


Figure 2. The percentages of the different advantages stated by students in (a) Course I, (b) Course II, (c) Course III.

The first major advantage the students mentioned is clarifying the instructor's expectations. Out of the student responses from Course I, Course II, and Course III, about 40%, 23%, and 43%, respectively mentioned that the guide helps students see what process the instructor is

expecting, or it provides students with a clear understanding of what is expected in the problem (Figure 2 (a-c)). Students also mentioned that the guide provides them insight into the appropriate steps that should be taken and "greatly clarifies misunderstood instructions and desired deliverables." This notion is shared by all students across the three different courses.

The second major advantage of the guide most students mentioned is organization. Students believe that the guide provided them a "clear and concise outline" or clarified the order the solutions should be delivered for clarity, thereby helped "with organization if one is poorly organized." With the knowledge of the clear expectations, students stated that the guide helped them to be strategic with their time and helped the students know what to focus on if they ran out of time. It is the authors opinion that if the students follow the outline of the guide and are organized in the problem-solving process, consistent and uniform solutions can be delivered.

The similarity in which the students structure their solution was found to facilitate the grading. With the grading criteria on the side, the instructor was able to assign appropriate points next to each element pertaining to the students work. This assisted the professor in maintaining consistency and homogeneity during grading.

As shown in Figure 2 (b) and (c), students in the higher-level classes also believed that the guide helped them to maximize their grades. This may be possible as the students can focus on the elements where they can earn the most points. Some students stated that with the guide " points can be gained even if problem is not solved" and "points can be obtained easier." Although these statements may not be accurate, the belief might have emerged due to the confidence and peace the guide brought to the test taker. As it can be seen from Figure 2(a) and (b), about five students mentioned that the guide and grading criteria made them develop a reasonable plan and consequently gave them confidence in solving problems. A few students also mentioned that the guide could help them see what they did incorrectly when reviewing their test (or facilitate feedback).

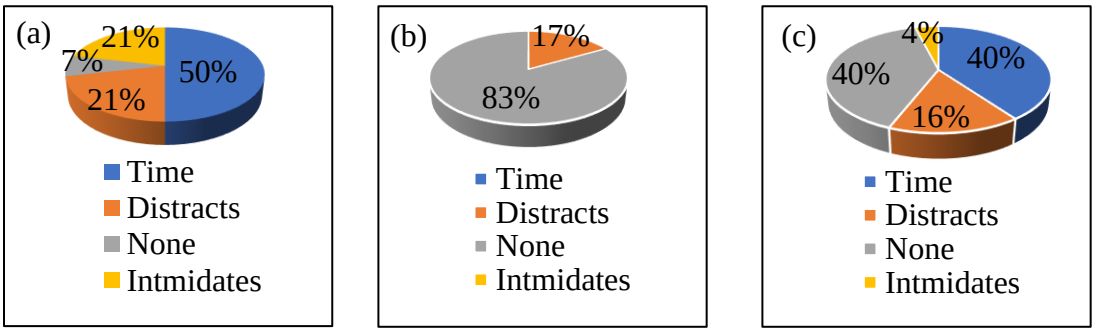


Figure 3. The percentages of the different disadvantages stated by students in (a) Course I, (b) Course II, and (c) Course III

There were four concerns raised by the students about putting a guide on the exam papers. As can be shown from Figure 3 (a-c), one of the biggest concerns is that it consumed time to read. However, some students found the additional time they spent was worth it. Others also found that the additional information provided distracted or intimidated. This could have resulted if the student failed to figure out how to process each element in the problem and realize how many points that cost him/her. One other reason could be that the additional information adds to the wordiness of the test and may cause students to just focus on the criteria rather than solving the

problem. The time issue can easily be fixed by providing the students additional time. Also, the authors believe that if the students were given prior notice about the guide and its purpose, they would have been better prepared in how to use it and not distracted.

Conclusions

Student responses to an open-ended question asking them to provide the advantages and disadvantages of adding a guide and grading criteria on exam papers was evaluated. Based on their responses, five advantages and three disadvantages were identified. It was found that the guide and grading criteria increased the students' confidence in knowing the instructor's expectation. Students stated that the knowledge of this expectation "brings peace" to the test taker. In addition, the guide helped students to organize the problem solution presentation, and to focus on the most important part of the problem and to demonstrate mastery of it. The instructor also found the guide helpful in evaluating the adequacy of the students' responses, maintaining consistency in grading, and providing clear feedbacks.

A few students stated that the time taken reading the guide and the additional information create distraction. This can be partly minimized by giving students additional time and by a well-designed guide and the grading criteria. Further study is needed to determine the impact of the guide and the grading criteria on the students' exam scores.

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