Effective Learning Strategies: Grading Rubric to Enhance Student Learning

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Abstract

Homework is a formative assessment to provide feedback to students regarding the new concepts learned on a weekly or biweekly basis. It also acts as a tool for the instructor to gage student learning outcomes. It provides real-time information to the instructor to design the coursework for effective student learning. This study aims to center a conversation about homework grading for new educators and provide one example of a homework grading rubric that is efficient and effective at providing feedback. A grading rubric was created to achieve the objective. To effectively understand the dynamics of varying student populations and backgrounds, the homework grading rubric study spans multiple classes at two higher education institutions to provide a comparative analysis of the outcomes. Time studies as well as student surveys are conducted to assess two outcomes; efficiency of the rubric and, effectiveness of feedback regarding the strengths and weaknesses in learning the course content. The study showed a decrease in grading time spent on the homework as well as the feedback helped in getting higher exam scores. Student surveys are being conducted during the 2019-2020 academic year.

Introduction

To teach engineering at the college level, one needs a doctorate in an engineering discipline. However, no formal education on teaching is required. A new instructor must seek out information about how to teach, translate their experiences as a student to their new role as instructors, or just use trial and error. If the new instructors use their experiences as students to design a course, then the selection of the latest ideas or traditional ones depends whether the instructor was exposed to application of pedagogical methodologies by their professors. Therefore, there will be a learning curve with the process, which will result in delayed effective learning of the students. The assessment and grading effects the student learning as well, and the learning curve associated with the entire process will affect the students' learning in general. Therefore, this study seeks to be a starting point for new instructors in improving their homework assessment which will in effect help the students' learning and success.

While grading homework, several factors might be considered. These include, but are not limited to, the total number of points for the assignment, the relative weight assigned to each question, and the number of points to take off for various errors. There is also an option of using a rubric used by a senior instructor but there are two problems with it; not every instructor might be using it and the new instructor might not be familiar with the rubric and its technical details. This

would again create a non-uniform grading process affecting the student success. Before using the grading, rubric developed and used in this study, the effort made to grade homework assignments was agonizing due to the struggle over allocation of points between various problems and to maintain consistent and fair grading between students and assignments. This established the need for a grading rubric that could not only make the process more uniform and consistent but also reduce the grading time, resulting in a higher grading efficiency. The rubric is a step towards specifications grading or ungrading—the term used to describe getting rid of grades—by employing minimal grading as discussed by Elbow [1], which seeks to provide feedback rather than rank students. Tobin [2] presents a reading list of articles about ungrading. Though the rubric studied still uses numbers, the aim is to communicate to students how well they understood the concepts in a problem. This in turn allows the students to use their numerical grade to determine if more time is needed to learn certain topics in the course material. Grigg [3] performed a study in which effort was made to use a newly developed assessment tool named PROCESS. The problem with the tool was that it was applied for first year students only, which limits its application and the study reported mixed results. The study also showed limitation of the tool for one segment of students. Similarly, studies [4, 5] were also limited in their scope to freshman engineering students and first-year instructors. The study [5] performed showed some details but it is still under progress so detailed analysis is not available. Other studies [6] were limited to only certain courses, and the rubrics cannot be applied to other engineering courses.

The present study assesses a homework grading rubric which has five levels. The tool is used for sophomore through senior level engineering courses to show its wide application. A time study is conducted to determine the efficiency of grading for the instructor, and a survey is administered to students to assess the effectiveness of the rubric in conveying feedback about their level of understanding on a homework problem. Overall, the rubric improved the grading efficiency for the instructor and most students internalized the feedback the rubric was designed to impart.

Methodology

The research looks at the effectiveness and efficiency of a homework grading rubric developed to convey to students their level of understanding of the concepts. The research is conducted at two universities, St. Ambrose University (SAU) and University of Wisconsin - Platteville (UW-P). All homework at UW-P were graded online. At SAU the grading rubric used does not require checking for specifics that are different for each problem. The grading rubric is shown in Table 1. The rubric tries to minimize the number of levels in the scale to increase efficiency for the grader while maintaining enough levels to communicate to students their understanding of the concepts in the problem. In addition to the rubric shown in Table 1, the grading rubric at UW-P has a set of five points looking at specifics of the problem as shown in Table 2.

In order to ascertain the effectiveness of the rubric, study participants answered a survey instrument. The efficiency of the rubric was measured using a time study.

Table 1. Homework Grading Rubric

Conceptual Question	
2/2 Points	Correct answer and thorough explanation/answer. Shows complete understanding of the concept.
1/2 Points	Answer shows some understanding of the concept but the answer is not complete or contains some incorrect information. Little to no supporting explanation.
0/2 Points	Unattempted problem, incorrect answer, or incomplete problem due to lack of understanding. Little or no supporting explanations.
Calculation / Critical Thinking Problem	
5+/5 Points	Correct answer and thorough supporting work. Logical steps are used throughout the problem. Proper units and significant digits provided.
5/5 Points	Correct answer to within a sign (+/-), trivial (math) mistake, but shows thorough supporting work. Proper units and significant digits provided.
4/5 Points	Incorrect answer due to minor mistake in math or concept, thorough supporting work shown, but incorrect or insufficient. Possibly not all parts of problem completed or attempted.
3/5 Points	Incorrect answer due to a mistake in math or concept, thorough supporting work shown, but incorrect or insufficient. Possibly not all parts of problem completed or attempted.
2/5 Points	Incorrect answer due to major mistake in math or concept, some supporting work shown, but incorrect or insufficient. Possibly not all parts of problem completed or attempted.
1/5 Points	Incorrect answer or incomplete problem due to major error. Little or no supporting work shown.
0/5 Points	Unattempted problem or back-of-the-book answer, with no work shown at all.

Table 2. UW-P Additional 5 Point Rubric

Problem Structure	Description	Points
GIVEN	Information provided in the problem statement including various parameters and word statements	1
FIND	Unknown parameters required to be determined	1
GOVERNING EQUATIONS	Equations that will be used to determine the unknown parameters	1
ASSUMPTIONS	Correct assumptions required for the solution of the problem or to simplify the math	2
SOLUTIONS	Algebraic solution with correct order of determining the unknown parameters along with the Free-Body Diagrams. Every answer should be **BOXED**, and the word **"ANSWER"** mentioned along with the box. For these points, follow the grading instructions in Table 1.	5

Survey

To determine the effectiveness of the grading rubric in conveying to students their level of understanding the concepts of a problem, data from a survey was collected. There were two survey instruments. The first was the initial survey in which students answered questions related to their basic demographics. The initial survey is intended for further study into effects of demographics, which is a work in progress. The second survey instrument asked participants to reflect on the grading rubric and determine the meaning and accuracy of their scores on individual problems and a set of problems in communicating their level of understanding of concepts covered. Table 3 lists the questions asked in the survey.

UW-P students were asked the same questions about the solutions portion as shown in Table 3 and one additional question, namely: By using the structure provided at the start of the problem, I can break down the problem in logical steps and understand the concepts as well as the steps to complete the problem to the following degree. The question used the same agree/disagree scale as questions 4 and 5 in Table 3.

Table 3. Homework Survey Instrument

Question	Scale	
1. A 3/5 on a homework problem means I understand the concepts asked about in the problem to the following degree 2. A 2/5 on a homework problem means I understand the concepts and applied them to solve the problem to the following degree 3. A 1/2 on a conceptual homework problem means I understand the concept asked about in the problem to the following degree	Not at all A Little Some A Lot Totally	1 2 3 4 5
4. I feel that my overall score on one of my homework assignments effectively communicates my level of understanding of the course content covered in the homework. 5. I feel that my overall score on one of my homework assignments matches my level of understanding of the course content covered in homework.	Strongly disagree Disagree Neither Agree Strongly agree	1 2 3 4 5

Time Study

To determine the efficiency of the grading rubric in Table 1, a time study was conducted to determine grading time for homework problems. The problems were separated into the two types, conceptual and calculation or critical thinking problems, matching the rubric. For each problem, the grader times how long it took to grade all students and tallied the number of students who were graded.

Results

One hundred and eight students were surveyed over four classes at two institutions. The breakdown of students and classes is shown in Table 4. The homework survey results for each question are totaled and broken down by class and school in Figures 1-6. The grading time study results for the rubric in Table 1 yield an average of 11 seconds (N=25 problems) per student spent grading a conceptual problem and 41 seconds (N=42 problems) grading a calculation / critical thinking problem.

Table 4. Students Surveyed

School	St. Ambrose University (SAU)		University of Wisconsin - Platteville (UW-P)	
Class	Electronics (Junior)	Heat Transfer (Senior)	Mechanics of Materials (Sophomore)	Fluid Dynamics (Junior)
Number of Students	13	20	45	30

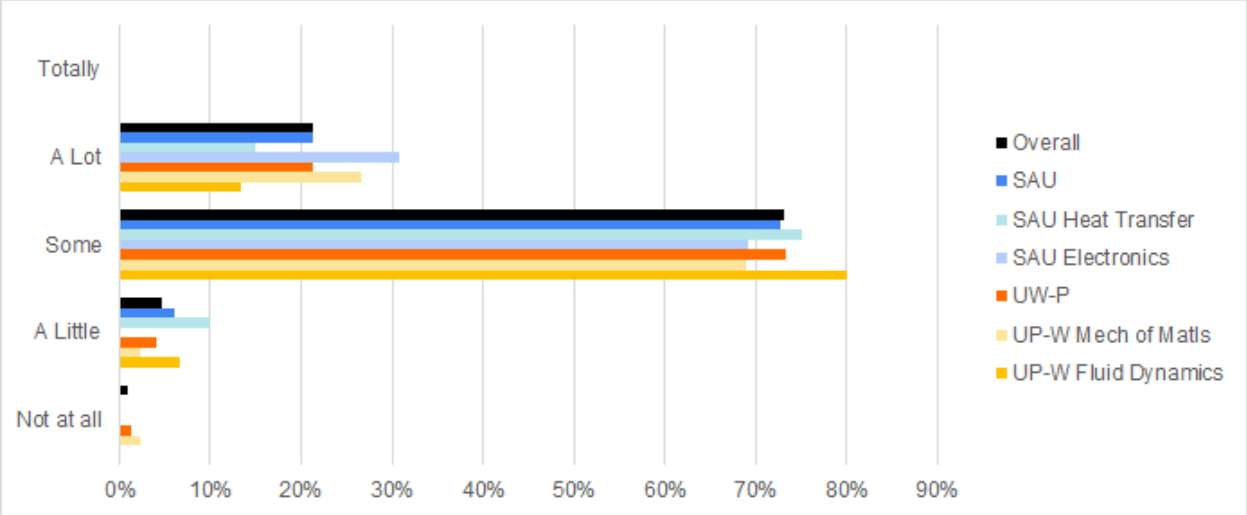

Figure 1. 3/5 on a Homework Problem Survey Question Results

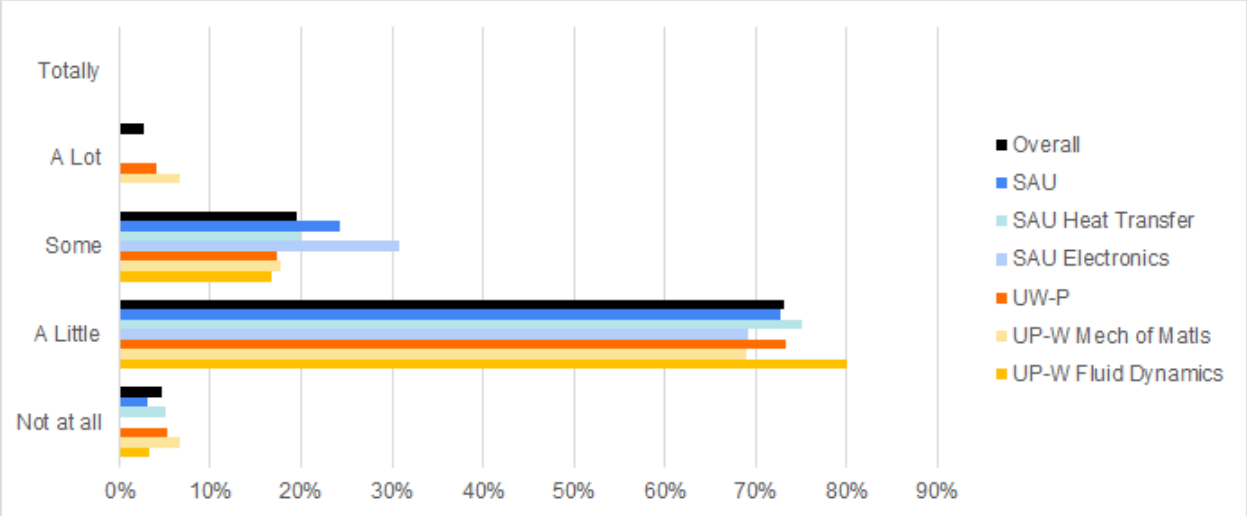

Figure 2. 2/5 on a Homework Problem Survey Question Results

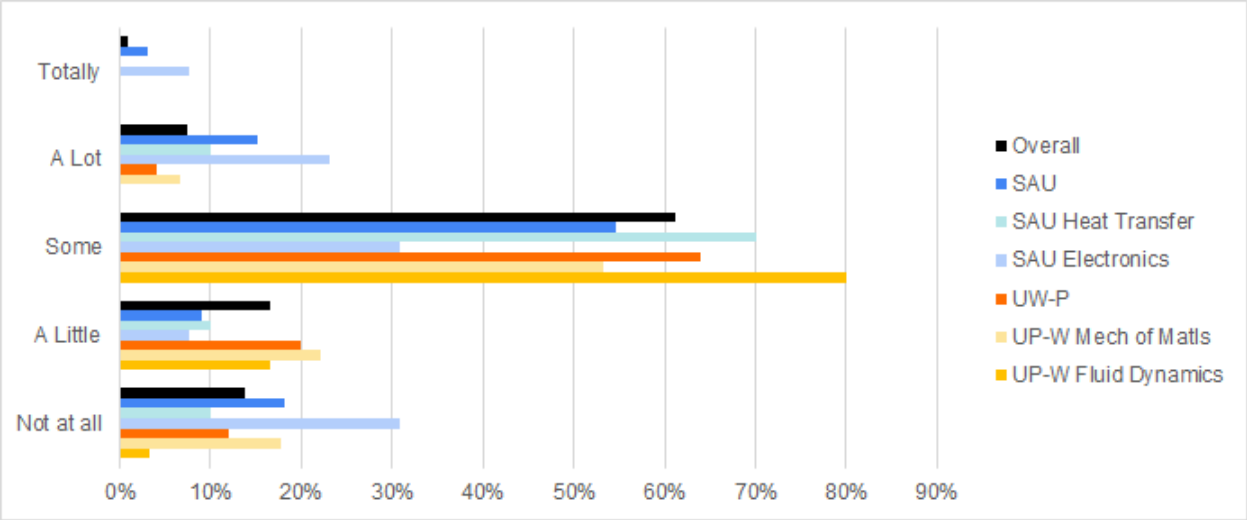

Figure 3. 1/2 on a Conceptual Homework Problem Survey Question Results

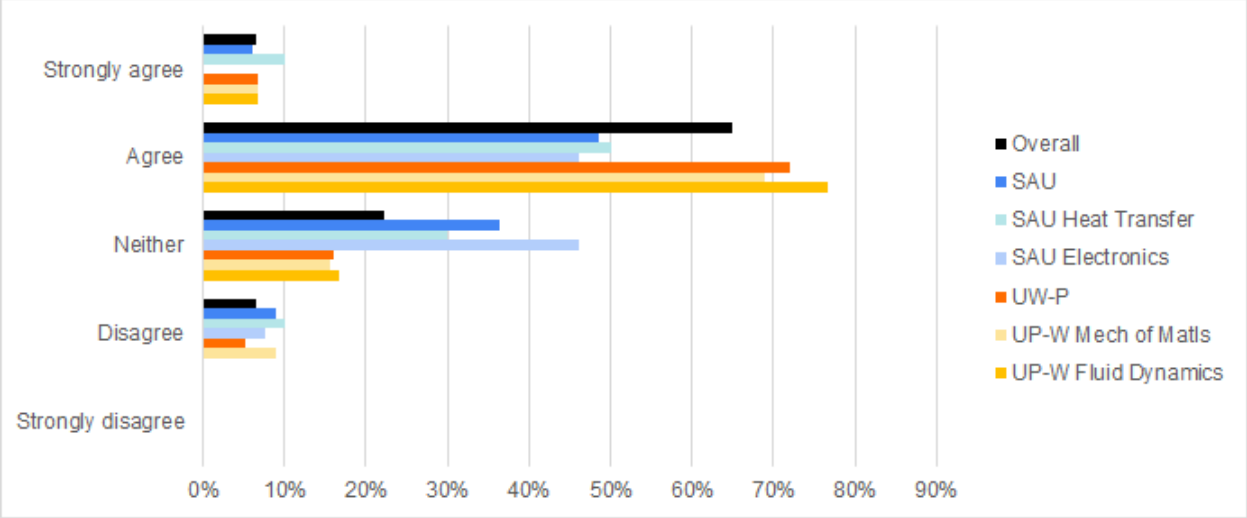

Figure 4. Overall score versus Effective Communication of Level of Understanding

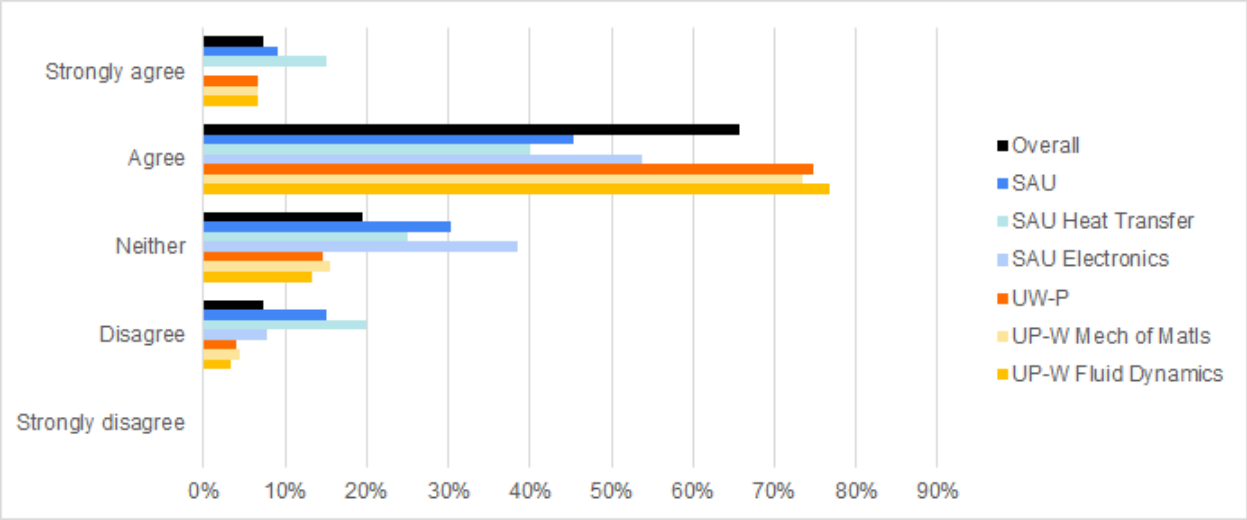

Figure 5. Overall score versus Matching of Level of Understanding

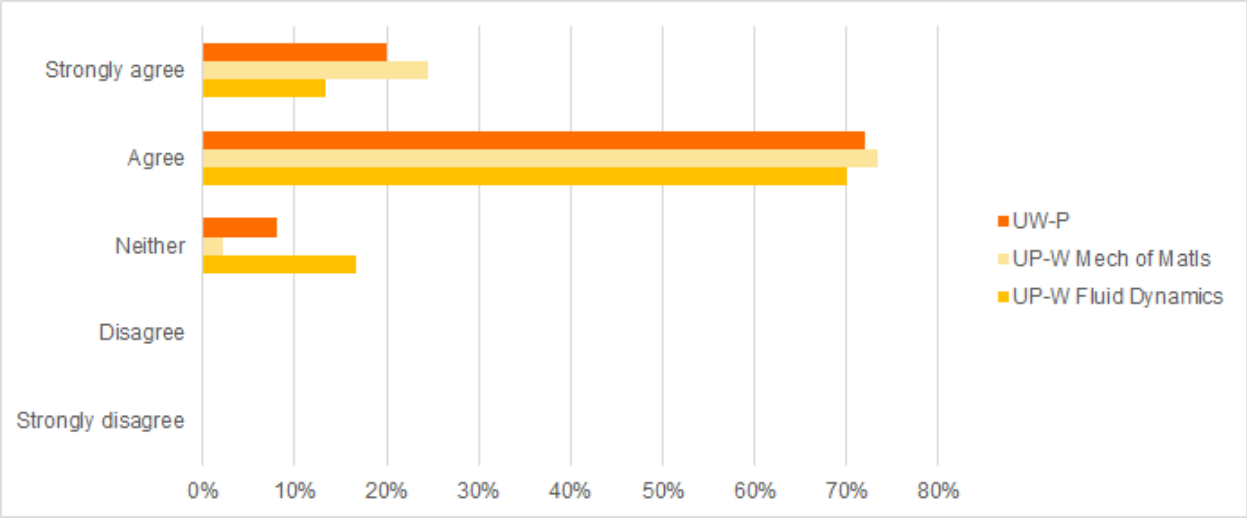

Figure 6. UP-W Structure Survey Question Results

Discussion and Conclusion

The homework grading rubric proved an efficient tool for the instructors as well as an effective tool for communicating the level of understanding of the concepts to the students. Each survey question shows majority of students internalize the intended feedback from the rubric.

Previously, the homework graded without using a rubric used to take at least two or three instructors/graders to grade a weekly homework assignment consisting of 6-8 questions for 10-15 students. In a worst-case scenario, assuming all the questions were calculation / critical thinking questions, an eight-question homework would take less than 6 minutes per problem on

average to grade or 82 minutes for 15 students using the rubric in Table 1. The reduction in time by using the rubric is noticeably less than the prior practice when grading without the rubric.

The survey results regarding calculation / critical thinking problems showed that students were able to connect and associate their assigned grades with the feedback from the rubric which created a fair, uniform and consistent grading system. In Figure 1, the majority of the students, 73% overall, felt that a 3/5 on a homework problem meant they understood the problem concepts "some" which matched with the rubric in Table 1. When students were asked about 2/5 on a homework problem, majority of the students, 73% overall (Figure 2), felt they understood the problem a little. According to the rubric, this corresponds to a major mistake in their solution matching the survey results. This effectively conveyed to the students their understanding of the problem, which helped identifying the weak points to students as well as the instructors. This was helpful because the instructors were able to focus their energies towards the weak concepts so the students could learn them better as well succeed in their exams. The rubric served as an early alert for the students so they could focus their learning efforts and ultimately culminate in their success.

Additionally, the survey result for the question on conceptual problems also show students are internalizing the problem grade with the rubric but to a lesser degree than calculation / critical thinking problems. As show in Figure 3, only 61% overall but still a majority of students felt that they understood the problem some, which matches with the rubric. One reason for the drop in the average may be that the scale of the survey matches the scale or the rubric for calculation / critical thinking problems whereas for conceptual problems the rubric only has two levels.

When looking at the overall score on a homework which totals the score for all problems, in Figure 4, most students (71% overall), agreed or strongly agreed that their overall score effectively communicates their level of understanding of the course content covered in the homework. Additionally, in Figure 5, most students, 73% overall, agreed or strongly agreed that their overall score matched their level of understanding of the course content covered in homework.

All homework at UW-P were graded online using annotations. Online grading proved very helpful for the students as well as the instructor to identify the weak points. Contrary to the notion of online grading being less helpful for students, the study showed improvement in communication.

Based on the time study and survey results, the authors recommend that instructors rethink their assessment for engineering courses, specifically homework, and adopt a form of minimal grading. The survey also consisted of demographic questions; that will be analyzed as the study

continues. The rubric that was developed and studied here coincided with the authors foray into the literature on grading. It was an enlightening process that could help other instructors as well.

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