

Homework Assignment Self-Grading: Perspectives from a Civil Engineering Course

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Introduction

One of the inherent challenges that instructors face with student learning is gauging the depth of student understanding. The assignment of homework problems serves as one way to determine how well the student is comprehending the information from preceding in-class lectures and associated readings. The homework set allows the student to gauge his or her level of understanding and for the instructor to determine how well individual students and the class as a whole are performing.

The task of grading these homework assignments, however, can be time-consuming and challenging, particularly if there is a significant number of students taking a course and if the nature of the problems makes it difficult to grade. As an example, long-answer problem sets, common in most engineering courses, will take considerably longer to review than multiple choice or true-false-type questions, so in larger classes where the instructor does not have a grader available, the instructor must decide how much effort to spend when grading the assignment. Fundamentally speaking, the student would benefit the most when errors in a problem are clearly flagged so that the student can learn from his or her mistakes. When class size is prohibitively large, the instructor may not be able to offer such detail on an individual level. In these cases, the instructor may simply mark down points when he or she encounters an incorrect response.

For this study, junior-level students taking a Fundamentals of Transportation Engineering course were asked to self-grade their homework assignment and the appropriateness of their grading was subsequently reviewed by the course instructor. This paper discusses: how this process was administered and the challenges associated with this approach, student feedback based on this form of assessment, lessons learned from the perspective of the instructor, and the key administrative and organizational aspects that must be in place in order for this approach to be effective for the student and manageable for the instructor.

The remainder of this paper is presented in four distinct parts. First, an extensive literature review describes previous studies related to student self-assessment and its techniques and how self-assessment benefits the students when administered properly. Second, the methods used to administer student self-assessment, in the form of self-grading, are described. Third, the results and analysis of this self-grading exercise are shared, in terms of the scoring differences between the student and the instructor, and whether this scoring differential changed with time. Qualitative feedback provided by the student based on this experience is also discussed. Lastly, the takeaways from this study and opportunities for future work are highlighted in the conclusion section.

Literature Review

Educators actively seek out opportunities that provide the best possible environment for students to succeed, but the interest and investment level of each student is highly variable. Huff and Johnson [1] and Ndoye [2] noted that when students take responsibility and are more aware of their expectations they often become more enthusiastic about their own learning. This recognition strengthens their personal sense of responsibility to: own the learning process, recognize the value of doing well, self-identify learning gaps, and commit to higher learning achievements [2], [4]. McMillan and Hearn [5] noted that students who experience success with challenging tasks will “attribute their success to ability and effort rather than to external attributions such as luck or help from other students.” This conclusion mirrors the findings of a study by Sluijsmans, Dochy, and Moerkerke [6] who determined that the amount of “meaningful energy” contributed by the student represented the most significant variable for effective learning.

Learning can be categorically differentiated between the surface learning and deep learning approaches of students. In the surface learning approach, students focus on completing tasks, often with limited effort to achieve minimum expectations, and do not necessarily focus on their potential for learning [7], [8]. Comparatively, the deep approach is one in which the student truly desires to understand and learn content [9]. Baeten et al. [10] determined that success of a deep learning approach is attributed to several factors including teaching and assessment that focus on the student, student satisfaction and interest with the course, and specific student characteristics such as age and gender.

In related terms, Dweck [11] differentiated between the mastery and performance goals of students. He described a mastery goal as one in which the student “focuses on the task at hand and (the steps needed to) improve knowledge, understanding, and skill.” Comparatively, a performance goal focuses on outcomes and “whatever can be done to ensure the outcome.” As a result, the final score is valued with performance goals while proficiency and learning are the focus of mastery goals. Pintrich and Schunk [12] recognized that a teacher can play an important role in reinforcing to students that mastery of subject matter is controllable and knowledge attainment supercedes task completion.

Defining Self-assessment and its Activities

In order to foster the abilities attributed to learning, the student must be able to self-assess his or her work. Self-assessment can be described from two different perspectives. On one hand, self-assessment is a process of enabling students to: become “more critical and perceptive” in their learning, make personal judgments on their learning outcomes and academic activities, and experience “holistic development” [13], [14], [15], [16]. Goal-setting activities and self-reflection performance are part of an overall process where the ultimate goal is to “grow oneself” and fuel future learning needs by examining individual performance, monitoring and evaluating thinking and behavior, and finding strategic ways to improve understanding [5], [17], [18], [19].

Self-assessment can also be specifically viewed as the ability of a student to reliably evaluate one’s own work and to complete tasks such as properly self-grading personal assignments.

Students are expected to make judgments and evaluate their work based on a set of criteria or standards and to correct answers and personal misunderstandings [5], [16], [20]. These assessment activities are designed to provide feedback to students while furthering their motivation and achievement [5]. To be effective, self-assessment criteria should be understandable, measurable, realistic, and relevant to the outcomes [18].

Self-assessment activities inherently benefit the student in a number of different ways. Students are expected to complete tasks and know how to complete them, increase their level of responsibility with regard to learning, increase awareness of in-course expectations and requirements, engage in continuing learning, and further their development of evaluative skills and strategies [2], [21]. Students are encouraged to pursue deeper levels of learning and understanding while avoiding practices such as short-term memorization and studying alone that are generally viewed as unfavorable tactics [4], [21].

An important component of self-assessment is self-judgment, in which students develop a better understanding of what they already know, and perhaps more importantly, what they need to know [22]. This increases the student's own role in learning by developing self-feedback habits and identifying future steps so that a better understanding is gained in terms of solving the problem rather than just deriving a solution [5], [6], [20]. When students persist on tasks, increased student learning independence, decision-making responsibility, initiative, motivation, and confidence results in a more meaningful learning environment [4], [5], [23], [24]. Students may feel a greater sense of ownership with their learning process when it requires their active participation and this process now becomes uniquely their own [4], [16], [25].

As is often the case, students are frequently less inclined to complete tasks that are not assessed since feedback or a reward is not provided [8], [13]. For this reason, it is hoped that self-assessment will allow for the "tuning of learning by the learner" rather than expecting that same learner to "wait for others to intervene" [26].

Self-assessment Benefits for Students

The ability of a student to properly self-assess his or her own work is an important skill; when equipped with the appropriate skill set, lifelong learning benefits that are cultivated over time can extend from their existing studies into the future as part of professional practice [13], [27], [28]. When asked about the self-assessment mechanisms that contributed to learning, students cited a number of elements including immediate feedback, clarification of expectations, identification of weaknesses, and a positive learning environment [2]. Sadler and Good [28] and Hattie and Timperley [29] each concluded that feedback had a positive effect by increasing student learning and further understanding of the material taught. Self-assessment promotes self-reflection, problem-solving, and more responsibility for learning and students recognize that they can learn from their own mistakes [6], [30]. The opportunity to judge the correctness of answers serves as another chance for students to further their understanding [28].

The benefits of self-assessment activities are not limited to the student; a course instructor can, if techniques are implemented properly, find himself or herself enjoying some time savings associated with course activities. While the use of self-assessment techniques should not be

initiated simply to reduce workload, it is recognized that grading activities are frequently viewed negatively and as being time-consuming [13], [24]. Furthermore, with increased student populations in the classroom, strategies to efficiently assess student work deserve consideration and will be embraced by staff and administration if properly administered.

Self-assessment Limitations and Challenges

The ideological benefits of self-grading assume that all students will honestly and consistently assess themselves. Numerous studies have flagged this particular condition when self-assessment or self-grading is administered. Specifically, there is simply a lack of consistency on the part of students. Past studies have consistently determined that lower-achieving students have a tendency to inflate their scores and overrate themselves. Conversely, high achieving students occasionally underrate themselves, although the magnitude is not quite as significant and neither tendency necessarily changes the rank-order of students [4], [13], [16], [28], [31], [32].

When student assessments do not mirror the results of the instructor then the formal use of self-assessment and self-grading may be jeopardized [13], [28]. Sadler and Good [28] point out that multiple-choice and fill-in-the-blank questions result in more consistent outcomes, but there is less agreement with open-ended responses; these trends begin as early as the middle school level. Other studies have identified inconsistencies between male and female students (males rated themselves higher), older and younger students (older students are more reliable) and peers versus oneself (peers were rated higher and the rating was done so with more confidence) [6], [14], [31], [33], [34]. Crowell [24] discovered that students felt that they graded themselves harder than their instructor.

This leads to the question of whether students, who may not have participated in assessment activities or be familiar with the concept, can serve as reliable judges of their own work; this requires them to understand the evaluation criteria, their level of effort and the perceived task difficulty, and provide the appropriate feedback needed to improve [13], [31], [35]. While students can be expected to improve with time, consistency levels among students are inherently inconsistent [6], [36] and can be attributed to students placing little value on self-assessment activities, being overloaded with other tasks or courses, and anxiety or stress [18], [21], [37], [38], [39].

When assessment is inappropriately applied, Boud, Cohen, and Sampson [21] stipulate that students will be inclined to take the surface approach to learning and aim to “beat the system” rather than engage in meaningful learning. Boud [13] suggests that if students cannot demonstrate the ability to produce acceptable self-evaluation marks then self-assessment should merely serve as a learning activity that is limited in scope. Brown and Harris [40] contend that a lack of accuracy prevents students from even knowing if they are learning. Beumann and Wegner [4] describe self-grading experiences in which the teacher clearly identified the student copying a solution without any understanding; the math was correct, so points could not be deducted but the student clearly did not meet the intended learning objectives of the activity.

Successful Implementation of Self-assessment

Self-assessment activities rely on proper application by students. Sadler and Good [28] note that lower performing students may have difficulty understanding the assessment tools or feel pressured to report an inflated outcome. For these reasons, it is imperative that clear standards and explicit criteria with a clearly-defined rubric are provided, assessment responsibilities are shared between the teacher and student, and teachers rigorously review student activities and call out students when anomalies occur [4], [13], [24], [28]. Harrington [41] and Bruce [22] emphasize that assessment rubrics should promote learning by indicating levels of proficiency or performance levels as opposed to just scores for grades.

Self-assessment and self-grading activities, when applied correctly, can support the student as part of his or her learning process. For this reason, these activities should be viewed not as isolated practices but as part of the overall learning process [28]. Despite decades of research on these promising techniques, self-assessment remains somewhat of a “niche market for the enthusiastic” and self-grading activities, particularly on exams, “remain unlikely due to social, political, and logistical reasons” [16]. Since opportunities remain to develop consistent and systematic usage of these techniques, further study is needed so that the pedagogical and philosophical impacts of self-assessment are better understood.

Study Design and Methodology

Engineering problems are frequently complex with multiple steps, so assessing whether the student fully comprehended the content requires the grader to carefully go through the response to determine whether a math error (or multiple math errors) or a less obvious comprehension issue (identified by the incorrect use of a formula) yielded the incorrect final answer. There is also the possibility that the student did not fully comprehend the material but through an “educated guess” arrived at a final solution that was, in fact, correct; however, the student would encounter difficulty when a more complex version of the problem was presented or when the student, under stress, was asked to complete a similar problem in an exam environment.

A typical process of assigning homework is shown in Figure 1a. The steps are straight-forward; the instructor assigns a set of homework problems and the student is given a set amount of time to complete these problems before submitting to the instructor to grade. The instructor reviews the homework set and then returns to the student with a score based on the correctness of the solutions provided.

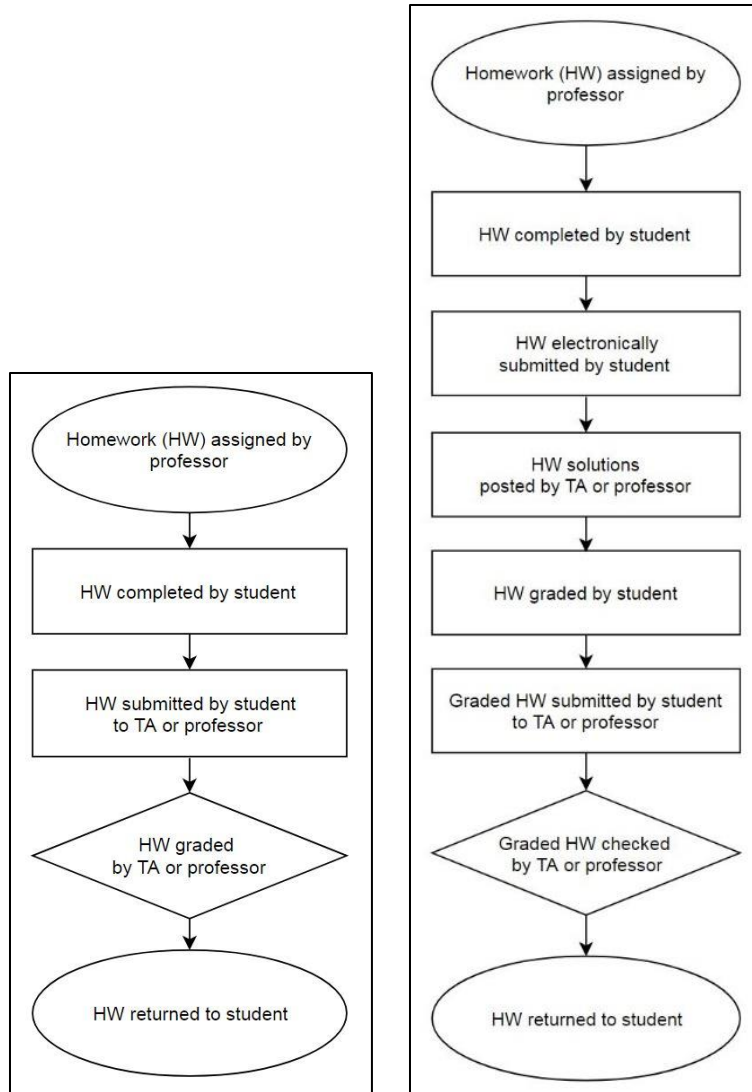


Figure 1: a) homework grading process (typical); b) homework self-grading process (by student)

By comparison, the implementation of student self-grading (see Figure 1b) for this study required several additional steps. The rationale for these steps will be described in the following paragraphs, and this study was reviewed and approved by the university’s Institutional Review Board.

For this study, each homework set typically comprised of eight to ten problems. A majority were stock problems assigned directly from the textbook; however, at least two problems from each set were uniquely developed by the instructor. This approach was implemented since textbook homework solutions are often available from paid online sites (such as Chegg [42] or Slader [43]) or found in the test files of student living groups. While students may choose to use these resources as an opportunity to supplement their learning, the instructor may view these same resources as a detractor to the learning experience. For these reasons, the creation of “homemade” problems ensured that students would not have access to a readily available solution.

On the due date, students were required to submit an electronic copy of their assignment in the form of a .pdf or image. While this intermediate step may seem counter-intuitive (in other words, why not just have the students turn in after grading?), the purpose was two-fold. First, it allowed the instructor to determine if the student had, in fact, completed the assignment on time. Second, this submitted documentation minimized the likelihood of the student making changes to his or her assignment when access to the solutions was granted. (Alternately, instructors could omit this step if an honor code was implemented and enforced, and there is reliable student compliance.)

Once this initial submission deadline passed, paper hard copies of the solution set were posted in a locked, glass-encased bulletin board to allow students to self-grade. There were several reasons why homework solutions were provided in this manner. First, this approach ensured that students could not claim that they had not received the homework solutions. Second, this approach minimized the likelihood of electronic copies finding their way into student test files for use by next year's students.

Students were provided with a qualitative grading rubric. Each problem was worth five points, and students determined their total for each problem based on these scoring guidelines:

- 5 - Completely correct; answer is correct and all of the necessary steps are shown.
- 4 - Minor error; process is correct but there is a minor error such as an arithmetic error, calculator error, typo, etc. It is clear from the submission that the student knew how to solve the problem correctly but made an error.
- 3 - Conceptual error; most of the process is correct, but one or more steps or equations are missing.
- 2 - Partially correct; one or more of the correct steps or equations are present, but most of the steps are incorrect or missing.
- 1 - Completely incorrect; student attempted the problem, but none of the required equations or steps are present.
- 0 - No submission.

Students turned in a copy of their graded homework to the instructor typically one week after the solutions were posted. This provided the students with sufficient time to identify where mistakes were made, if any, and to tally their final homework score.

After the graded homework assignment was submitted, the instructor then checked the student submission prior to returning back to the student, typically by the next class.

Results and Analysis

At the conclusion of the semester, the cumulative scores from the self-grading exercise for all of the homework assignments were compiled. As described earlier, this study sought to determine: 1) how students performed with regard to this self-grading activity (i.e., did student scores differ from those of the instructor?) and 2) if self-grading performance improved over time (i.e., did scoring differences between the student and instructor diminish over time?)

A total of 103 homework assignments, representing thirty-five different students, were assessed as part of this study. For this class, the instructor checked the homework assignment of every student for the first homework set. For each of the remaining six homework sets, the instructor reviewed a randomly chosen subset that ranged from nine to eighteen students.

Comparison of Student and Instructor Scores (Individual Assignments)

To assess overall student self-grading performance, the graded homework scores from all assignments (ordered from lowest to highest) is shown in the top portion of Figure 2. The lower portion of the graphic identifies the difference between the score graded by the student and then by the instructor. (As an example, the first set of data indicates that the instructor gave the student a grade of 58 for this particular homework set; this score was ten percentage points *lower* than the score previously determined by the student.)

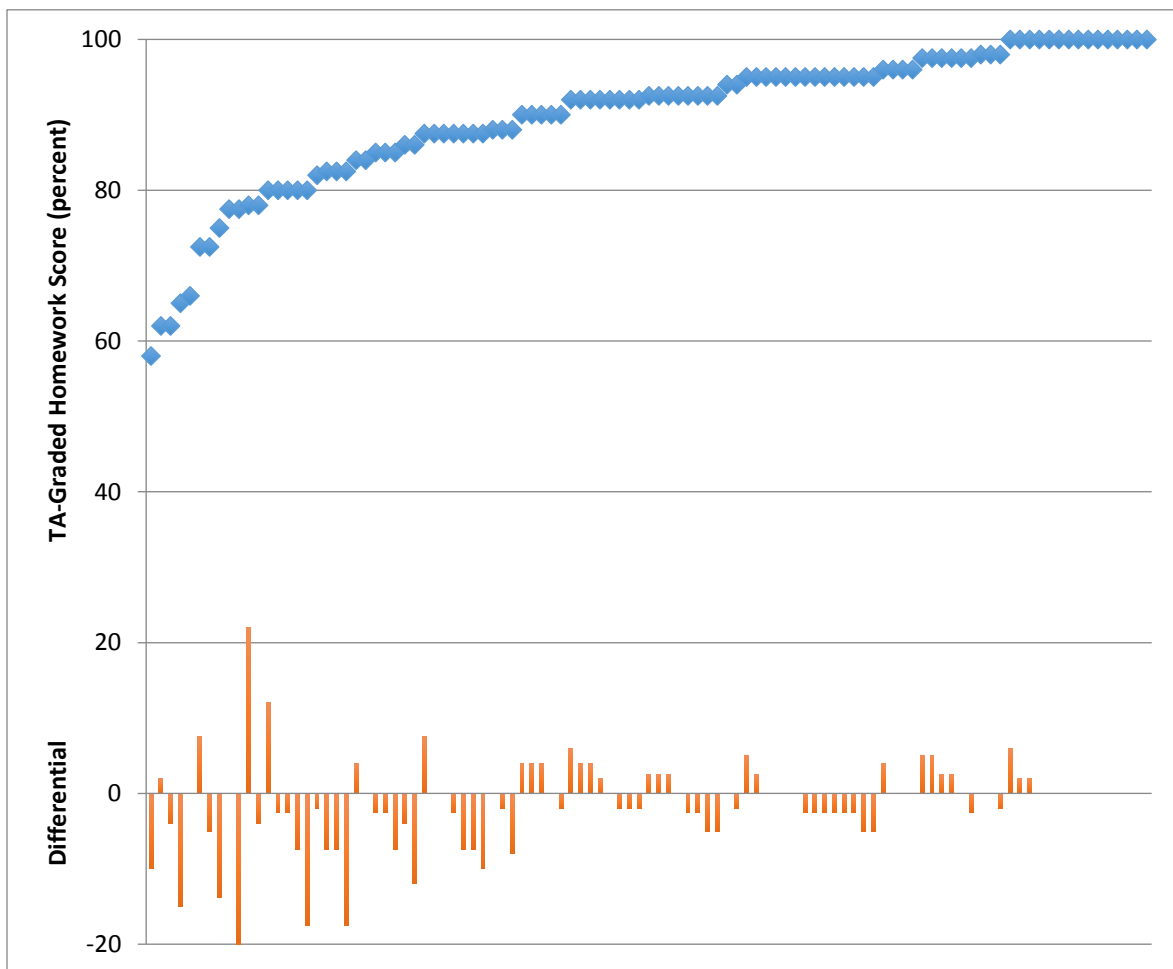


Figure 2: Scoring Differential between student and instructor (sorted from lowest to highest homework grade)

From this graphic, two key trends are identified. First, disparity occurred more frequently when students performed poorly and the score differential between the instructor and student decreased as students performed better. In other words, students who performed poorly generally arrived at

a significantly different outcome from that of the instructor. Second, when there was a disparity, the instructor typically concluded that the student deserved a lower score (as evidenced by the frequency of a negative scoring differential). In this study, of the 38 cases where the student received a grade less than 90 percent, there were only six cases in which the instructor felt that the student deserved a higher grade.

Comparison of Student and Instructor Scores (Temporal Effects)

The second objective of this study was to determine temporal attributes of student self-grading and if student scores trended closer to the instructor over time.

Table 1: Statistical comparison of student and teaching grades over time

HW#	# of Assignments	Student Grade		Instructor Grade	
		Average	SD	Average	SD
1	33	88.4	10.9	89.9	9.6
2	10	88.0	12.1	85.4	12.2
3	10	96.5	4.4	94.3	5.7
4	11	94.3	5.1	90.7	6.4
5	9	94.7	3.8	93.3	4.4
6	12	92.7	7.2	93.1	6.5
7	18	89.8	8.8	85.1	10.0

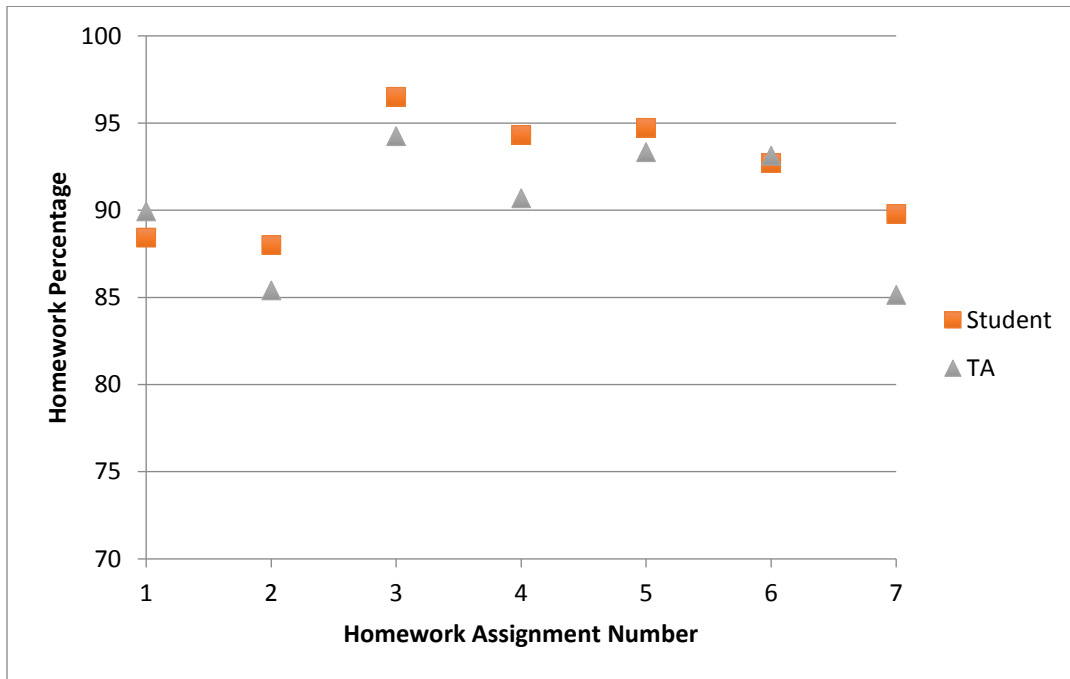


Figure 3: Graphical comparison of student and teaching grades over time

Table 1 and Figure 3 summarize the average percentage and corresponding standard deviation of student self-graded scores with those of the instructor. The results indicate that in four of the seven homework sets the average score between the student and instructor varied by more than

two percentage points. In five of the seven homework sets, the score determined by the instructor was lower than the score determined by students. Ironically, the greatest disparity between the average score as determined by students and the instructor occurred on the final homework assignment. However, despite these subtle differences, there was no significant difference between the scores determined by the student and the instructor based on an independent sample t-test conducted comparing the scores of each homework set. (A p-value, or calculated probability, was obtained from the results in which a value greater than 0.05 would have suggested that the mean or variance was not significantly different.)

Student Feedback

The qualitative feedback provided by students suggests that the implementation of self-grading was a polarizing method. Some students embraced this approach, although further analysis would need to be conducted to determine if this approach would still be favorable after any perceived novelty wore off.

“It was my first experience with this kind of self-grading and I liked it.”

“Relooking at problems was very helpful to see where I went wrong for some solutions.”

Other students were not as enthusiastic or even critical of this approach. In particular, students found the electronic submission process to be tedious and intrusive.

“I didn't see an upside to it. I didn't mind doing it however.”

“It didn't really make sense.”

“I don't feel that we gained much and scanning the assignment in was a hassle.”

“I very much hated this format. I did not get anything from this format.”

“Personally I did not benefit much from this because I generally got the problem completely correct or was not even close. I found the grading an additional step and due date to remember, and was not worth it.”

“It really didn't help me learn more because I mostly just looked if I got the answer right and if I did (most of the time), I moved on.”

When homework assignments are frequently assigned, this process can be somewhat confusing (i.e., informing students that one set of ungraded assignments is due for electronic submission while another set is to be graded and turned in, potentially on the same day).

Students also expressed their desire to have electronic access to the solution set.

“Electronic copy of the answers online would have been helpful, especially since the electronic submission was required.”

“Electronic submission was definitely easier when done on Mathcad. The few mistakes made on the homework were not huge but I did learn from them.”

“It would be nice to be able to grade our homework at home with a .pdf copy of solutions.”

“I thought the answers should be sent out the day the electronic submission was due so you could grade them then.”

It should be noted that students could have taken static shots of the solutions set using their mobile device and then graded the homework in the comfort of their home without having to physically stand next to the bulletin board (though many students were observed doing so).

At the end of the semester, the students in the class (N=35) were asked to evaluate the self-grading process on a five-point Likert scale.

- With regard to the self-grading process, students collectively held a slightly favorable view (M = 3.63, SD = 1.37), with 1 = unfavorable and 5 = favorable.
- With regard to the electronic submission process, students collectively held a marginally favorable view (M = 3.21, SD = 1.32), with 1 = unfavorable and 5 = favorable.
- When the students were asked if they “learned more” with self-grading versus the traditional method of homework grading, the overall class somewhat supported this statement (M = 3.35, SD = 1.29), with 1 = strongly disagree and 5 = strongly agree.

While the overall intent of this self-grading exercise was to give students another learning opportunity as they completed their homework assignment, it was observed that some students completed their self-grading during the break immediately before class on the day that the graded assignment was due; in retrospect, this defeated the purpose of the self-grading exercise. As an alternative, students could be asked to qualitatively explain why a mistake was made, if one occurred. This tactic might be more conducive to learning; if the student is not grasping the root cause(s) associated with errors in thinking then the effectiveness of this approach misses its intended objective.

Conclusions

A homework assignment represents one method to gauge student comprehension, provided the student is doing his or her own work and focused on the assignment. This research sought to evaluate how the additional effort of student self-grading contributed to their learning. The results were mixed, with some students seemingly focused on how the process could be streamlined from a submission and review standpoint rather than on the learning aspect itself. From an instructor standpoint, while this method reduced the cumulative amount of time required for homework grading, it also represented a potentially missed opportunity to provide additional and detailed feedback to students.

This study uniquely added to the body of knowledge by examining student self-grading in an engineering course of study and qualitatively described how the experiences of these engineering students compared with the results from earlier studies. Many of the outcomes from earlier studies were confirmed in this study, including those that described how poorly-performing students would be inclined to test the boundaries of self-grading and how the skill of self-

assessment is not one that can be easily learned, especially if students are not committed to the overall process with regard to the homework grading activity.

The results from this study suggest that there are opportunities to refine the overall process. One option would be to require students to identify where and why they made mistakes *and* provide a corrected version of the problem, potentially for added partial credit. This would require additional effort on the part of the student which, in turn, may cause them to be even more leery of the learning intent if self-grading is already a technique that is loathed. Additionally, it is worth considering how, if in any way, the impacts of self-grading in this transportation engineering course translate or transfer to other classes. In other words, are students inclined to focus more attention on their assignments in other classes? Is this self-grading approach one that would be embraced in other classes? These are questions that should be answered if such a study was conducted on a broader level and using more than one course.

Instructors could also use the findings from this study to explore a hybrid approach to grading. The homework assignments of students with a higher self-graded score could be scanned over quickly (since these scores were generally consistent with those of the instructor) while more time and feedback could be devoted to the assignments of those students who gave themselves a lower self-graded score. This could serve as one opportunity for the instructor to strategically manage his or her workload if time is limited.

Acknowledgement

The author wishes to recognize this course's teaching assistant for his help with the administration of this self-grading study.

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