Online, Handwritten or Hybrid Homework: What's best for our students in the long run?

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***Abstract*—Some educational software packages allow for homework to be submitted through the web. These have provided opportunities for students to practice solving problems with a *guided* solution process. They can receive instant "programmed" assessment regarding input. Faculty have the ability to assign problems from the book as homework and it can be graded automatically. Software and book choice can mitigate time savings for the professor, requiring problems be manually coded, but overall, the use of software decreases time required to administer the homework. Methods of delivery (online only or hybrid classes) can also have a large effect on the time and effort committed to a course. However, the use of online homework systems does not instill the importance of presenting a logical and organized solution; it is missing a technical communication aspect of an engineering education[1]. This is an important characteristic that is missing in recent engineering graduates[2]. The use of online homework can be beneficial in developing a solving process and retention of material [3-4], but lacks assessment of organized solution processes; something required is most engineering classes. Preliminary work in assessing "presentation of an organized solution process" and its correlation with the final course grade has been done in two sophomore mechanics classes. Early analysis indicates, that with training, students who perform well on a presentation score of a rubric also perform well in solving a problem: almost 70 percent of the problem solving process can be predicted by a presentation score.**

Index Terms—Online Homework, Handwritten Homework

Introduction

Current research shows there is little evidence to indicate online learning is significantly more effective that traditional methods[5]. While this is a larger debate that encompasses the delivery of lectures and lessons, our work focuses on the effect of online homework on the ability of students to communicate technical information in their homework, quizzes and exams. Research shows the ability to communicate technical information graphically, through sketches and diagrams is missing from our graduating engineering students[2].

We have used software packages in conjunction with textbooks that include online homework assessment and submittal. We have used these in sophomore mechanics classes and have experienced the benefits and frustrations associated with the use of these packages. Online homework has the potential to free many hours of time for faculty[4] to concentrate on research or perfect their lectures. However some evidence exists that in an effort to best assess student knowledge and enhance their ability to communicate one engineering faculty member commits 80 hours a week to ONE course[1]: an unsustainable side effect of online courses. Additionally, direct cheating is reduced, but not eliminated through the ability of software to randomize numbers. Finally, faculty can assign many problems for students to practice and perfect their problem solving skills.

From our experiences, there are still some bugs that need to be worked out with certain software packages. Students are often frustrated when there are only minor inaccuracies in their answers. Often students will give up on a problem solution, out of frustration (minor problems with free body diagram's (FBD's), force vectors and/or significant figures), sometimes sacrificing their grade on the assignment, even though they have a clear understanding of the subject matter[6]. In addition, depending on publishers and content used, much of the online content still needs development. In self reporting studies, students have indicated that they believe online homework is an effective form of assessment; indicating that their study habits improved and they believe the homework positively affected their final exam and final course grades[4, 7]. A study also showed that students were successful in the 2nd semester of this 2 semester science course sequence[4]. Students do generally appreciate the ability to instantly know if they achieved the correct answer and/or obtain hints to direct them to the correct answer. The ability to work many problems is also a benefit to students as they often ask to see more problems solved. Therefore, if extra problems are assigned, students can choose to ask for the answer and immediately see the entire solution [3]. Students also appreciate having a guided solution instead of a "blank-slate" (a blank sheet of paper) to start their problems[7]. However, informal surveys from students who use online homework systems at the same university have indicated that they much prefer handwritten homework submittal.

At large universities, with class sizes now exceeding 300 students per class, online homework may be the only way that students can receive feedback regarding their solving process. However, while working on homework, some students blindly follow each step without necessarily having a clear understanding of the problem solving process. In these larger classes, students do show high achievement scores on exams [8], but are not necessarily assessed on their skills in presenting a logical problem solving process or understanding of a problem through:

1. Restating the problem in one's own words,
2. Drawing a clear free body diagram,
3. Using consistent variable names between sketches and equations,
4. Aligning equations for ease of reading and debugging,
5. Differentiating between vectors and magnitudes,
6. Showing all equations used,
7. Using a consistent set of units, and
8. Indicating final solutions

Research has illustrated there is little difference in the final course grades of those who have received online homework versus handwritten homework[3]. We too show evidence to support this idea ($p = 0.148$). However, the missing piece in all of the online homework software, is an assessment of the presentation of students' work. The use of online homework can be beneficial in developing a solving process, but detrimental for classes that require illustrating an organized solution: which is still a necessary tool for most engineers[2].

Methods

We assessed homework in three classes using three different formats. In the first class, only online homework was assessed for the correct answer, with a reduction of points based on the number of attempts to get to the correct answer. In the second, online homework submittal was assessed similar to the first class, however, one randomly chosen handwritten problem was also graded using the same rubric used on exams. The rubric used a 0 to 4 scale over 3 different categories: 1) coordinate system and free body diagrams, 2) equations derived from the free body diagrams in the first category, and 3) the solution obtained from the equations and neatness of the solution. The final iteration of homework assessment did NOT include online homework at all. One randomly selected homework problem was collected and graded on a similar rubric as described above, where 20% of the score was reserved for the neatness of the solution. In this study, our proxy for presentation of a solution is the overall "handwritten" homework score.

We conducted ANOVA analyses to determine if there was a difference between online homework and handwritten homework. The data was collected across three semesters from one instructor's class. Each semester collected a different type of homework; 1) online only (O only), 2) online and handwritten (O and H) and 3) handwritten only (H only). In each case of the online homework submittal, multiple attempts were allowed. Future studies will consider limiting the number of attempts.

There were minimal counts of repeating students between delivery modes. Three students took a class in which homework was assigned as online and handwritten. However, due to overall course grade, they then repeated the course in which handwritten homework was required. With only 3 repeating students, and different methods of scoring for homework assessment, each student's score was treated as an independent score in the analysis.

In addition, mode of lesson delivery was consistent throughout the study. Each class was delivered in a consistent format across each class typically using 3 problems per lesson. The first problem is used to set up material and illustrate concepts through problem solving. The second problem is delivered in a "flipped" method, in which students work on a problem individually or as groups. The final problem is solved together, instructor and class, in which the class leads the solution with only minimal instructor intervention.

Results

Analysis of the data indicate that there was a significant difference ($p = 0.018$) between two classes, online with handwritten and the handwritten only. The handwritten only final grade was an average of approximately seven points lower than the class that used a combination of online and handwritten homework. A potential cause of this difference is that the homework average is included in the final grade and there was a 23.1 point difference in the homework averages between those two classes. Another potential cause for this difference is higher homework grades due to students being allowed multiple attempts on the online homework problems. In each of the classes final grades and final exam grades are contrasted with the homework grades.

As stated above, there was a significant difference in the final grades of two classes. Figure 1 shows a boxplot, with mean scores, for the three classes and the final grade. However, when analyzing class compared to the final exam grade, there was no significant difference ($p = 0.348$) between the classes. As stated previously, we believe the significant difference with the final grades is due to the fact that the final grade was partially based on the homework grade.

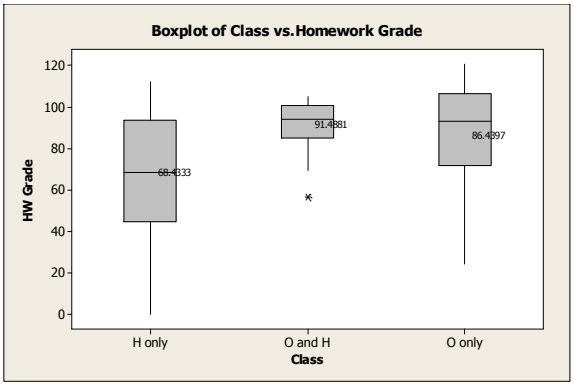

Figure 1: Class Grade vs. Homework Method (H-Handwritten & O-Online)

The second analysis broke the homework grade, regardless of delivery method, down into the corresponding A – F grades using a standard grading scale

(e.g., >=90 is an A, 80 – 89 is a B, etc.). The results of the second analysis show that there was a significant difference ($p = 0.005$) between the letter grade on the homework and the final exam grade. Students having an 'A' average on the homework scored, on average, 14.4 points higher on the final exam than students having an 'F' average on the homework.

Discussion

These data do support the idea that delivery methods for homework do not impact student learning. However the opportunity for faculty to instill the importance of a engineer's ability to communicate effectively[9] (through technical sketches, free body, energy flow, and cash flow diagrams) are missing when students are only asked to do online homework. These data also indicate that a combination of online and handwritten homework is significantly better than handwritten homework alone. There may be several reasons behind this higher homework average: here, we suggest three. First, students are working homework problems before entering their solution into the online software. Second, students are using the online software to guide their handwritten solution and therefore spend more time on their handwritten solution. Finally students get one more opportunity to practice their problems solving skills with a requirement to turn in a handwritten solution.

We suggest, in the field of engineering, it may be best to use introductory classes to develop and establish the presentation and organization skills along with a rigorous problem solving process, on which other classes can build. Evidence exists to suggest that technical communication through sketches is an ability that is lost on this generation of students[2]. Therefore, using online homework, alone, in the freshman and sophomore level courses may be detrimental to the student and future engineer. In upper level classes, students may be required to present a logical problem solving process in their handwritten work, but will not have had the opportunity to practice those skills. Without this opportunity to practice students may graduate without an ability to communicate effectively with our current engineering force.

Conclusions

Studies discussed here have investigated the use of online homework in classes whose value was assessed by correlating homework grades to final grades and through student surveys [4, 7-8, 10-11]. However, few studies have assessed the effect of online versus handwritten homework on the success of students[3]. This study shows, through a similar correlation of homework grade to final grade, that there was no significant difference in the success of students as to if they did homework online, handwritten, or some hybrid combination of both.

We also suggest a longitudinal study should be developed to assess the effectiveness of online homework on a student's ability to communicate effectively in advanced classes. In the long run, our students are missing out on an important opportunity to develop their sketching and problem solving skills that will successfully carry them to other classes and into the work force.

The obvious short term tradeoff for using online homework systems includes a generally more accepting student body for similar material comprehension. And for faculty, depending on the online system chosen, online homework systems can lead to less time spent grading.
Early (unpublished) studies using a grading rubric with a category solely for assessment of "presentation of work" in handwritten homework show good positive correlation between overall problem solution and presentation score. This suggests that the ability for students to communicate effectively, through how well their work is presented, can have a positive effect on his or her own performance. These skills can be instilled using a small portion of a rubric of the handwritten homework score to assess and inform how to improve students' presentation skills. This is relatively easy in lower enrollment courses (30-36 students) in which professors can oversee the problem solving process. Some (like ourselves), have the ability to teach at smaller schools and can implement hybrid approaches of online and handwritten homework or simply handwritten homework to assess and instill the importance of effective technical communication. We are not sure what the solution will be in large enrollment courses.

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