



The Direct Relationship between Grade Dispersion and Submission Time

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The Direct Relationship between Assignment Grade Dispersion and Submission Time

Abstract

Students beginning a university degree program are often unaccustomed to the rigorous nature of collegiate homework assignments and may wait until the last possible moment to begin and complete their assignments despite forewarnings by their course instructors to start early. As students mature and gain more experience, many find beginning assignments earlier often results in a deeper understanding of the concepts and better overall assignment grades. With the increased use of digital systems to distribute and manage assignments several metrics including the first time a student views the assignment (starts) and when the student submits their solution (ends) are automatically tracked. Using such data, results from over 180 freshman engineering students enrolled in an introduction to engineering course are reviewed to explore the trend between submission times and scores received through assignment durations. Trends in the data show assignments submitted early fall into more favorable distributions based on score means and dispersions. Additionally, a relationship exists between the time of day the assignment is submitted and student performance. Data used to identify these relationships includes 12 assignments from four course sections in the Spring 2013 semester, nine assignments from two course sections in the Spring 2014 semester, and seven assignments from four course sections in the Fall 2014 semester.

Introduction

The cost of procrastination is often not quantifiable. However, analysis of two assignments from an introduction to engineering course at Texas Tech University produced a relationship between assignment grade and submission time as a function of time between the start and submittal dates. The relationships discovered in the Fall 2013 semester clearly illustrate the adverse effects of procrastination on student performance. The data used herein comes from 4 of 13 sections of an undergraduate ENGR 1315 - Introduction to Engineering course offered in the Fall of 2013, 2 of 13 from Spring 2014 and 4 of 13 from Fall 2014, at Texas Tech University. The three-hour course lesson meetings are on Tuesdays and Thursdays for 1 hour and 20 minutes, with 28 course meetings in the Fall semester of 2013, 30 in the Spring of 2014 and 29 in the Fall of 2014. The course covers an introduction to the engineering profession, different engineering majors, math concepts, basic problem solving, MATLAB programming, Excel basics and concludes with a team project. Prior to enrolling in ENGR 1315, students are required to take, and pass, a math placement exam and have already completed, or be concurrently enrolled in, Calculus I. The first lessons in ENGR 1315 include curriculum on time management, project management, successful homework strategies, how to study, how to prepare for an exam, and

exam taking tips. All of these initial lessons focus on teaching utility maximization to the students (for example: maximum retention, optimal performance, maximize the return on time spent studying, etc.) with respect to their time and efforts. Through the course of the semester, opportunities arose to reinforce these principles by deconstructing performance on homework assignments. The trends advanced in the paper were presented to the students at the midpoint of the semester in an attempt to leverage the students' perceptions that self-efficacy entails maximizing performance on tasks.^{1,2}

With increasingly more powerful computers, new online learning management systems (LMS), and data analytics collecting data to quantify homework performance has been easier.³ During the Fall 2013 semester, student complaints led to the discovery of two trends relating the times assignments were submitted and the scores received for multiple assignments. Data for the Fall of 2013 relating submission times with assignment scores was presented to the students for assignments with 40-hr and 112-hr durations. The disclosure of these trends did not result in any appreciable long-term change in student behavior based on data collected for subsequent assignments.

Fall 2013 Assignments

Assignments in ENGR 1315 are administered using an online LMS allowing the students to log in to complete the assignments at any time between the instructor defined release time and deadline. The questions used in assignments 1 through 7, with the exception of one publisher supplied question in assignment 6, were custom built to fit the course content.

Additionally, all the assignment generate different numbers, algorithmically, for each question and each student, providing a unique problem for each student. Thus, students can work together in groups, facilitating optimal utility maximization, while requiring each student to work out their problems with their respective values. Since the LMS was new to most of the students the first few weeks required troubleshooting and shakedown as the students became familiar with the process.

The dataset for the Fall 2013 semester includes 196 students enrolled in four sections on class day 1 (49 students per section) with 16 students (8%) having prior experience with the LMS utilized for assignment administration. The four questions types in the assignment sets are: computed responses, multiple-choice, fill in the blank, and identification. The first five assignments were released and collected prior to Test 1, Tuesday September 24, 2013. The overall opinion from the students was positive with regards to the LMS managed assignments. Assignment 6 was released at 8:00 am Tuesday September 17, 2013, 7 days prior to Test 1; and was due at midnight on Thursday September 19, 2013, 40 hours later. Assignment 7 was

assigned at 8:00am Thursday September 19, 2013, 5 days prior to Test 1; and was due Thursday September 26, 2013, two days after Test 1. Table 1 shows the calendar for these events.

Table 1: ENGR 1315 course calendar for weeks 3 and 4 in September 2013

September

Sun.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.
15	16	17 - HW 6 Assigned	18	19 - HW 6 Due - HW 7 Assigned	20	21
22	23	24 - Test 1	25	26 - HW 7 Due	27	28

Directly following the deadline for assignment 7, students in the four sections this data comes from, plus 7 of 9 other sections, complained assignments 6 and 7 were excessively long and required more effort than the previous 5 assignments. In reality, the assignment duration for assignment 7 was longer than any of the previous assignments by as much as 48 hours. Table 2 outlines the breakout of question types and assignment durations for assignments 1 through 5. The primary metric used for assignment comparisons is the number of responses versus assignment duration. For the first 5 assignments, the highest ratio is 1.150 and the lowest is 0.134.

Table 2. Assignments 1 through 5 durations and question types

	Assignment 1	Assignment 2	Assignment 3	Assignment 4	Assignment 5
Assignment Duration	112 hours	40 hours	112 hours	40 hours	112 hours
Number of Questions	13	13	23	14	14
Total Number of Responses Required	15	22	72	46	58
Number of Computed Reponses	10	7	0	0	2
Number of Multiple Choice Reponses	5	4	24	18	18
Number of Fill in The Blank Reponses	0	0	44	28	38
Number of Identification Reponses	0	11	4	0	0
Ratio: (# of Responses) / (Assignment Duration)	0.134	0.550	0.643	1.150	0.518

Table 3 outlines the breakout of question types and assignment durations for assignments 6 and 7. The ratio for assignment 6 is higher than any other assignments in assignments 1 through 7. The fill in the blank answers drove up the number of responses required on assignment 6, but were designed to be short duration questions asking the students to specify a single value in an array that satisfied a given matrix operation.

Table 3. Assignments 6 and 7 durations and question

	Assignment 6	Assignment 7
Assignment Duration	40 hours	160 hours
Number of Participants	173	177
Number of Responses Required	135	56
Number of Computed Responses	13	60
Number of Multiple Choice Responses	0	0
Number of Fill in the Blank Responses	122	5
Number of Identification Responses	0	0
Ratio: (# of Responses) / (Assignment Duration)	3.375	0.350

The submission times for assignment 6 versus assignment score are shown in Figure 1, the break in the data represents the night between the two days through the assignment duration when the students were most likely sleeping. Upon inspection, two trends appear to be present. First, the dispersion of scores increases with time. Second, the two separate chunks of data represent assignments submitted on day 1 (the left chunk) and day 2 (the right chunk). There appears to be an increase in dispersion as the time of day progresses.

When submission time versus assignment scores is plotted for assignment 7, Figure 2, the break between days is less obvious, probably due to the students' first exam falling inside of the assignment duration. The exam times for the four sections are blocked (in purple) to illustrate where the exam times fall in the assignment duration.

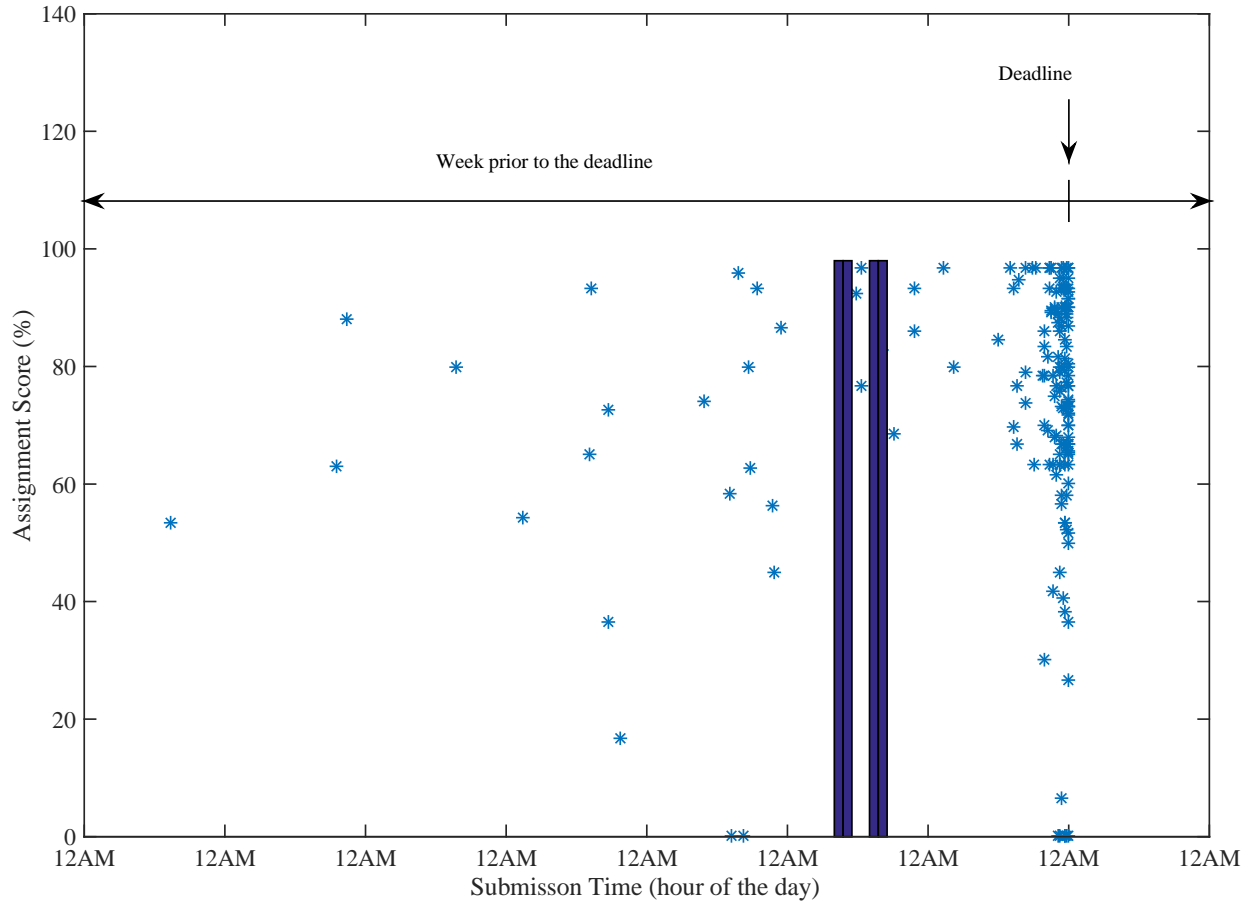


Figure 2 – Fall 2013 assignment score versus submission time for assignment 7

Assignment 8 had a 112-hour duration same as assignment 7. After presenting the trends between grade dispersion and submission time to all four sections, assignment 8 was investigated to determine if the students changed when they worked on and submitted assignment 8. A few interesting observations were discovered regarding assignment 8. First, one-fourth of the students submitted assignment 8 more than 4 hours before their respective assignment 7 submission time. The data in Figure 3 shows a greater number of submissions closer to the date of the assignment, suggesting students heeded the discussion relating grade dispersion versus submission time. However, close to 60% of the students still submitted the assignment in the last 12 hours before the deadline.

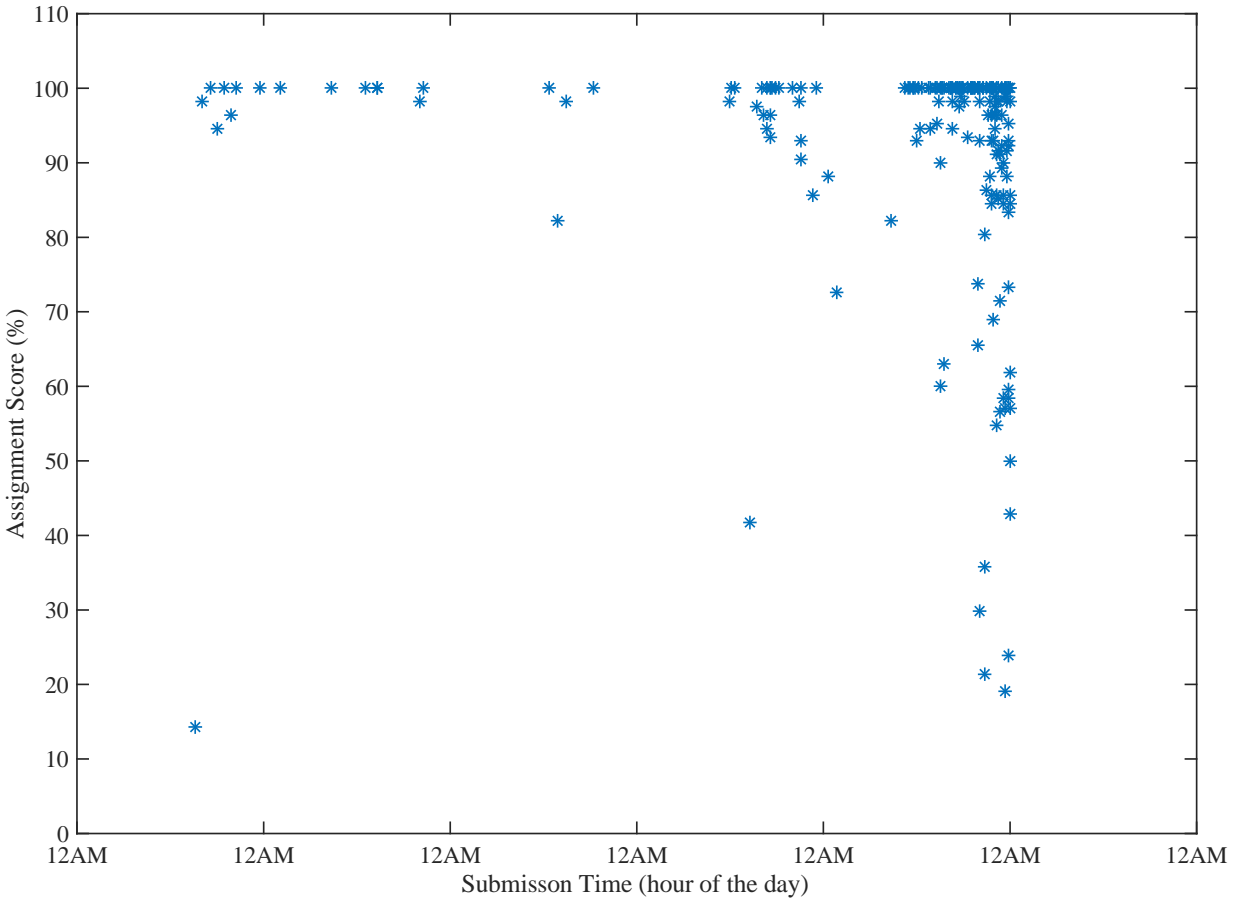


Figure 3 – Fall 2013 assignment score versus submission time for assignment 8

Through the remainder of the semester, three additional 40-hr assignments were assigned. The submission time for the 40-hr assignments versus assignment score are plotted in Figure 4. The data is broken into 4-hr windows and zero scores are removed from the dataset in each window. The mean of each 4-hr window is shown as a horizontal line spanning the 4-hr duration. The 99.7% upper confidence limit, 3 standard deviations above the mean (UCL), and the 99.7% lower confidence limits (LCL), 3 standard deviations below the mean are computed for each 4-hr window. The dispersion in each window is illustrated using a vertical line spanning from the UCL to the LCL centered in each 4-hr window. In cases where either of the UCL or the LCL exceeds the limit of possible outcomes, a minimum score of 0 and a maximum score of 100, the dispersion is capped at the natural limit. Figure 4 shows two very interesting trends including: the mean and LCL values trending down as time of day progresses, and as the overall assignment duration progresses.

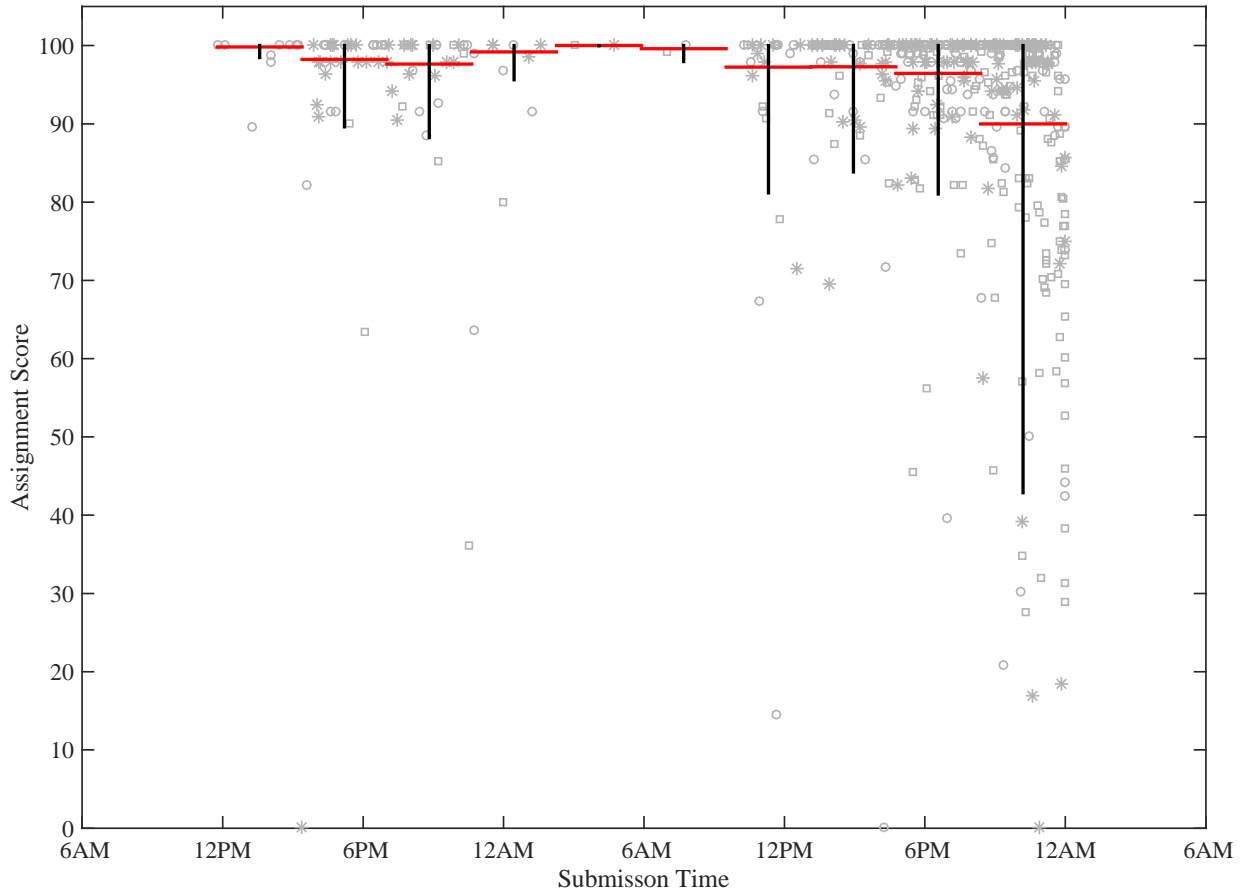


Figure 4 – Fall 2013 assignment score versus submission time for three additional 40-hr assignments; mean, upper confidence limit (+3 STD) and lower confidence limit (-3 STD) for 4-hr submission time intervals

Figure 5 is similar to Figure 4 illustrates the mean, UCL and LCL over 4-hr intervals for non-zero, non-outlier data, for seven 112-hr duration assignments administered in the Fall of 2013 semester. The increase in grade dispersion for the 112-hr assignments exhibits a decrease in the LCL for four hour intervals. Similar to Figure 4, the mean and LCL values trend down as time of day progresses, and as the overall assignment duration progresses. The trend in the LCL is not as pronounced in the middle of the assignment duration, but is present at the beginning (left) and near the due date (right). The reason for this is unknown, other than to say some variation is expected as student performance and decision making are random processes.

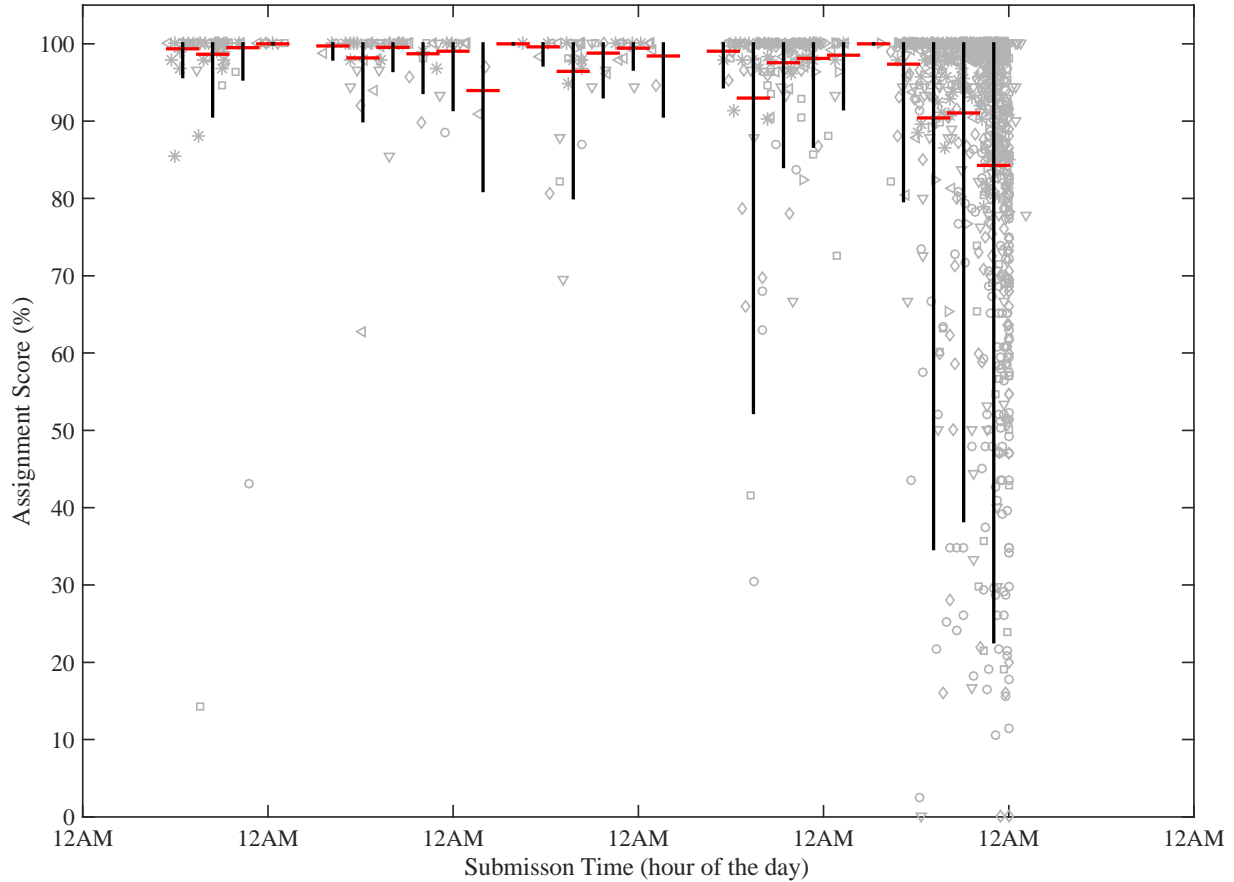


Figure 5 – Fall 2013 assignment score versus submission time for seven additional 112-hr assignments; mean, upper confidence limit (+3 STD) and lower confidence limit (-3 STD) for 4-hr submission time intervals

Data points exceeding the 12am due date represent either students submitting their assignments late, or data from assignment 19 when the due date was extended to 2:00 am, instead of 12:00 am. This extension was to accommodate several students needs but very few students took advantage of the additional 2 hours. The statistics for the final 4-hr window in Figure 5 include the scores submitted past 12am.

Spring and Fall 2014 Assignments

As an extension, data from seven additional sections in the Spring and Fall of 2014 were also analyzed for assignments having 40-hr and 112-hr durations. Due to changes in the way the course was administered, most of the assignments from these semesters took on durations other than the 40-hr and 112-hr format used in the Fall of 2013. For consistency, only data from 40-hr and 112-hr assignments in the Spring and Fall 2014 semesters are analyzed. No single assignments were independently analyzed like assignments 6, 7 and 8 in Figures 1, 2 and 3, respectively, from Spring 2013.

Figure 6 illustrates the dispersion of scores for four 40-hr assignments, administered during the Spring 2014 semester, plus the means and confidence limits for each 4-hr window. All four assignments have been normalized to the same 40-hr period. Figure 7 illustrates the dispersion of scores for five 112-hr assignments, administered during the Spring 2014 semester, plus the means and confidence limits for each 4-hr window. All five assignments have been normalized to the same 112-hr period. Figure 8 illustrates the dispersion of scores for three 40-hr assignments, administered during the Fall 2014 semester, plus the means and confidence limits for each 4-hr window. All three assignments have been normalized to the same 40-hr period. Figure 9 illustrates the dispersion of scores for four 112-hr assignments, administered during the Fall 2014 semester, plus the means and confidence limits for each 4-hr window. All four assignments have been normalized to the same 40-hr period. Figures 6 and 8 exhibit the same increase in dispersion with assignment duration illustrated in Figure 4 for the Spring and Fall 2014 semesters, respectively. The means in Figure 6 do not follow a clean trend like Figure 4 and the means in Figure 6 show little change but do decrease with time of day just as in Figure 4. Figures 7 and 9 illustrate the same increase in dispersion with assignment duration illustrated in Figure 6 for 112-hr assignments in the Spring and Fall 2014 semesters, respectively. Both Figures 7 and 9 exhibit the increase in dispersion as each individual day progresses but there are a few 4-hr windows that do not cleanly follow this trend. As this trend occurred in three consecutive semesters, it appears to be more than an aberration and deserves further study. The data for all 40-hr and 112-hr assignments from the Fall 2013, Spring and Fall 2014 semesters is presented in Figures 10 and 11, respectively.

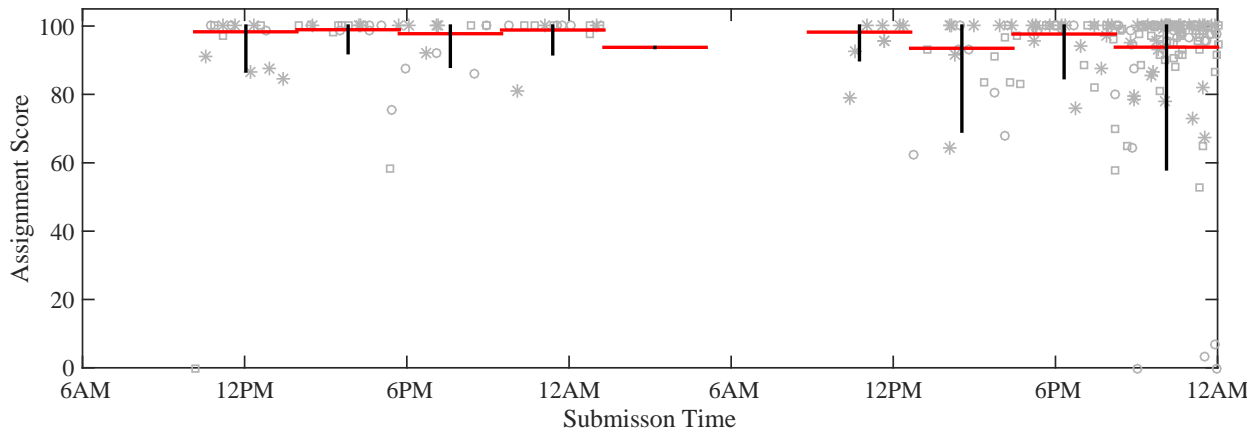


Figure 6 – Spring 2014 assignment score versus submission time for 40-hr assignments; means, upper confidence limits (+3 STD) and lower confidence limits (-3 STD) over 4-hr submission time intervals

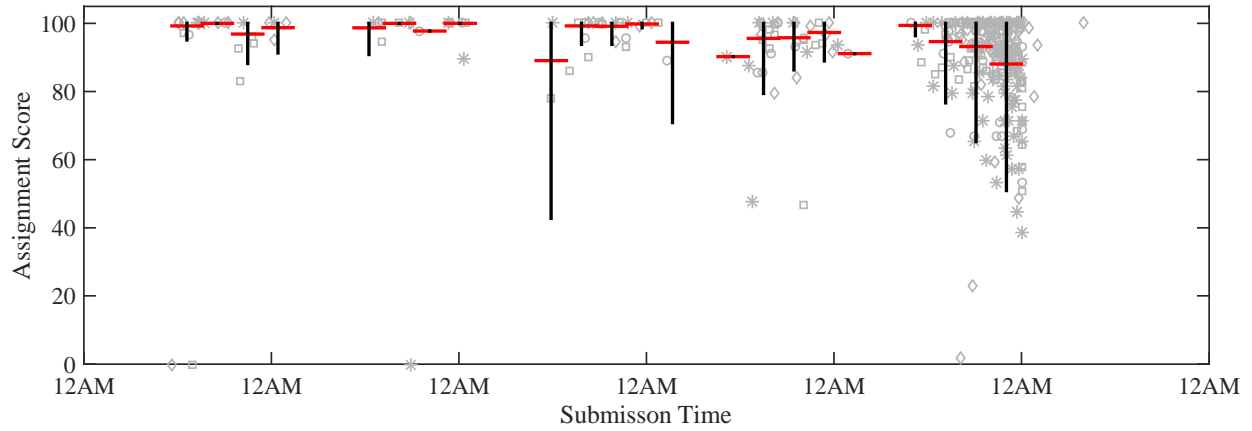


Figure 7 – Spring 2014 assignment score versus submission time for 112-hr assignments; means, upper confidence limits (+3 STD) and lower confidence limits (-3 STD) over 4-hr submission time intervals

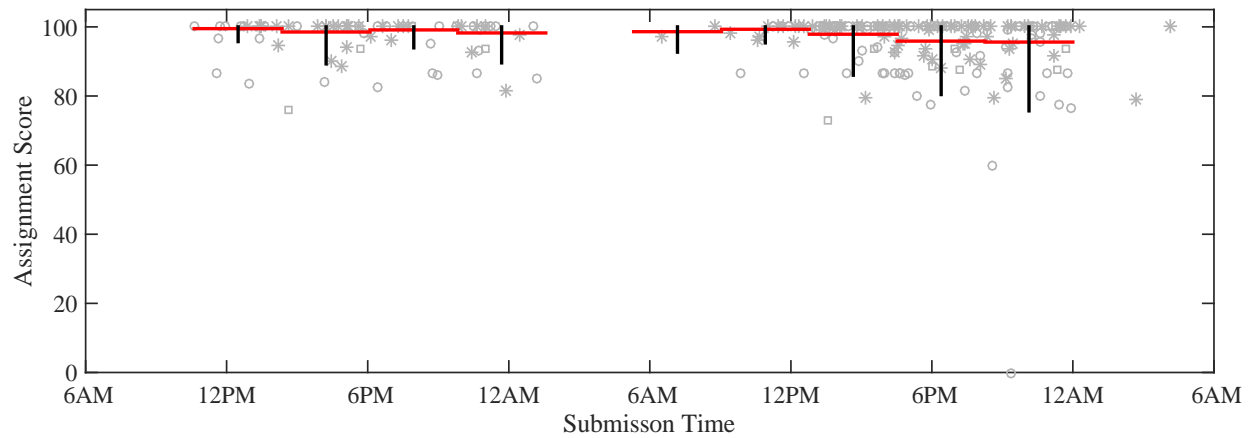


Figure 8 – Fall 2014 assignment score versus submission time for 40-hr assignments; means, upper confidence limits (+3 STD) and lower confidence limits (-3 STD) over 4-hr submission time intervals

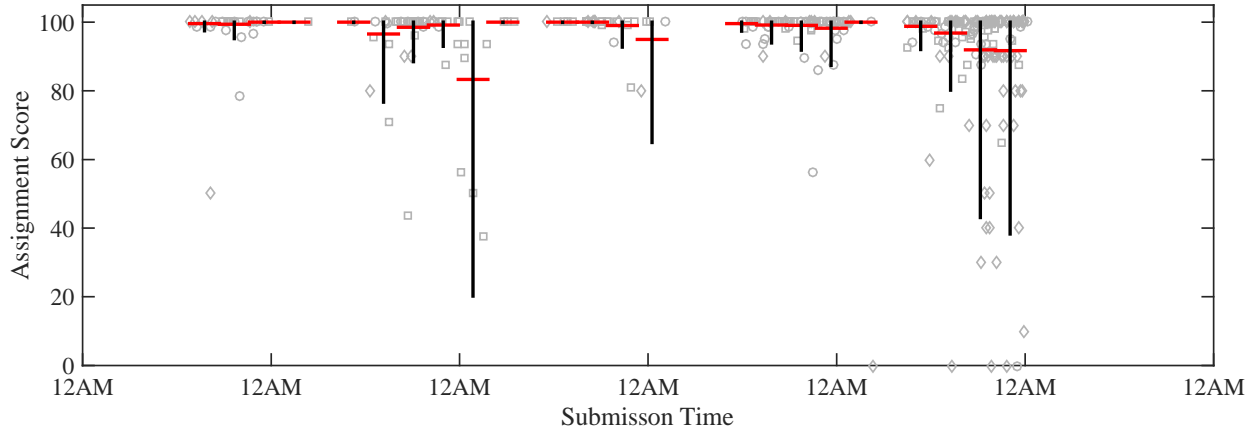


Figure 9 – Fall 2014 assignment score versus submission time for 112-hr assignments; means, upper confidence limits (+3 STD) and lower confidence limits (-3 STD) over 4-hr submission time intervals

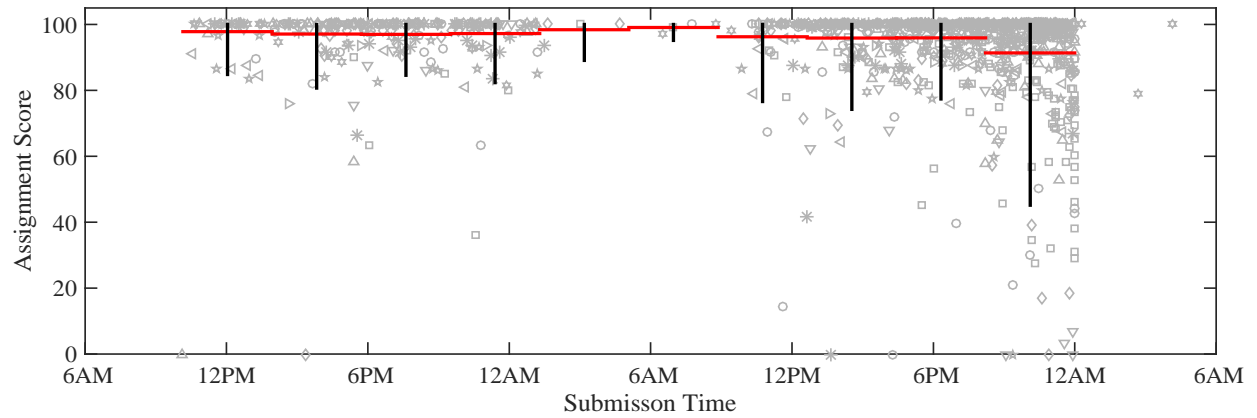


Figure 10 – All semester 40-hr assignment means, upper confidence limits (+3 STD) and lower confidence limits (-3 STD) over 4-hr submission time intervals

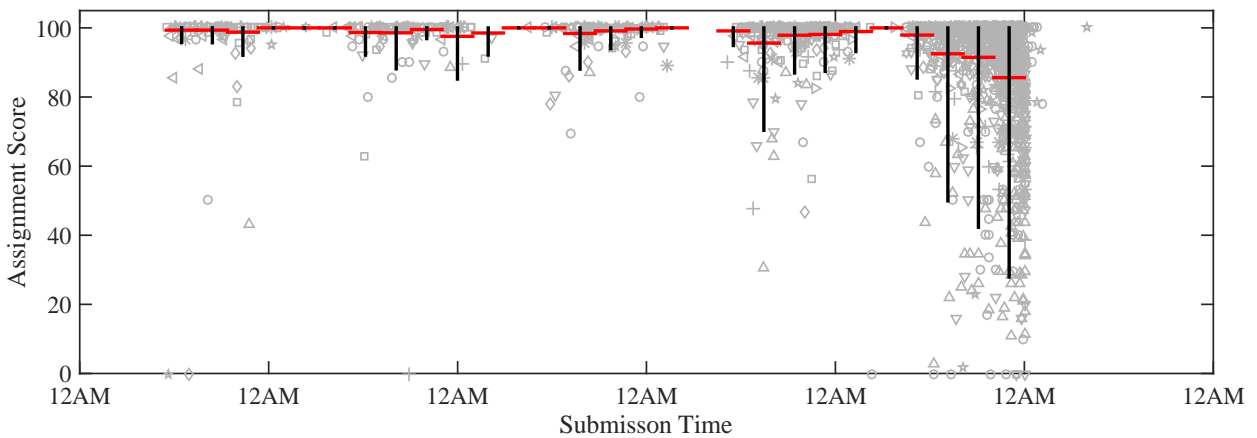


Figure 11 – All semester 112-hr assignment means, upper confidence limits (+3 STD) and lower confidence limits (-3 STD) over 4-hr submission time intervals

Discussion

The data in Figures 1 through 11 clearly show several interesting phenomena. First, very few submissions can be seen occurring between 1:00 am and 6:00 am every day. This time corresponds with normal sleeping hours so the absence of data during these intervals is expected.

Second, a clear relationship between the grade dispersion and submission times occurs over the 4-hr intervals supporting the hypothesis, procrastination negatively affects performance. Additionally, assignment scores tended to be higher when the submitted time was closer to the assignment date. This likely correlates to the freshness of the material covered in class, preparing the student to apply the principles on their own. When the student procrastinates, the material from the lecture is stale and more challenging to apply on their own. There are data points outside of the clearly defined distribution related to the time an assignment was submitted. These points represent students who perform below the base of the trend for the time their assignment was submitted. These outliers deserve more study than could be done herein.

Third, the increase in grade dispersion is the same for assignments of 40 and 112. This indicates the students that wait till the last minute to complete their assignments, do so regardless of whether they had 2 or 5 days to work on their assignments. As such, instructors may want to opt for smaller and more frequent assignments reducing the time between the lecture and the assignment due date maximizing the possibility students will be able to apply lecture content to the assignment before they forget it.

Fourth, the increase in grade dispersion can be seen in both Figures 4 and 5 for 40-hr and 112-hr assignments, respectively, for the Fall 2013 semester. The means decrease a small amount with respect to the time of day, but the means shift down by as much as 15% for distributions early in the duration of the assignment versus close to the deadline. For the 40-hr assignments, Figure 4 shows the same decrease in means occurring through the duration of the assignment. For the shorter duration, 40-hr, the trend of means decreasing with respect to the time of day assignments were submitted is clearer. For the first 7 intervals, the first 6 show a decrease in mean with time. The seventh interval saw a rise in the mean score and a decrease in dispersion, but the distribution contained a small number of data points so sampling may be an issue. Similarly to interval 7, intervals 8 and 9 contained little data but did see a return to a mean similar to earlier intervals. For the second day, intervals 11 through 20 saw the same trend of decreasing means with time. Interval 10, representing assignments submitted between 4am and 8am contained no data. These trends track in the Spring and Fall 2014 semesters with a few deviations but the data presented in Figures 10 and 11 illustrate three semesters aggregated together and the means can be seen to decrease with daytime progression for most days. Also, as the due date for each assignment draws nearer and nearer, the dispersion of scores grows.

Fifth, even after these relationships were explained mid-semester to the students for the Fall 2013 semester, very few changed their behavior and began submitting assignments earlier. There are data points representing outliers occurring outside of the clearly defined distributions usually occurring early in the assignment durations. These scores are very unfortunate as each assignment could have been attempted an infinite number of times allowing the students to achieve a higher score. These outliers deserve more study than could be done herein. The students in the Spring and Fall 2014 semesters were shown this data at the beginning of the semester, and at the midpoint as a refresher with still no noticeable change in performance.

Future Research

In addition to collecting comparable data in future courses of ENGR 1315 - Introduction to Engineering, a survey is going to be administered to attempt to ascertain the criterion students use in determining when to work on assignments. Such a survey may be difficult to use in a direct comparison as the student's habits and choices will change with every new semester, year, or decade.

Conclusion

Data from two assignments, from four sections of ENGR 1315 – Introduction to Engineering were used to identify a trend between assignment grade dispersion and submission time. The trend was explained to the students and very little change in outcome and therefore, behavior was observed. The remaining assignments from the same 4 courses were aggregated by assignment duration, as well as data from two additional semesters, and the same trend was identified and shown to be independent of assignment duration. This trend quantifies the cost of procrastination and can be used as a supplemental instruction tool to attempt to dissuade students from procrastinating on their work.

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