Student Performance Characteristics in a Hybrid Engineering Statics Course

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Introduction

In today's increasingly technology-driven world, nations must increase their number of workers with the appropriate Science, Technology, Engineering, and Math (STEM) skills to remain competitive. "[A] number of studies have shown that 50 to 85 percent of the growth in America's GDP is attributable to advancements in Science and Engineering,"[1] and to continue that growth, a capable workforce with related STEM skills will be required. According to a report from Georgetown University, "STEM occupations [in the United States] will grow far more quickly than the economy as a whole (17 percent versus 10 percent)."[2] However, the number of STEM-skilled workers has not matched this growth yet, as illustrated by the state of Delaware's STEM Council findings that "for every unemployed person in Delaware, there are 3.8 open jobs in STEM fields, and for every non-STEM job there are 1.7 people in the state."[2] Colleges and universities play an important role in the creation of the STEM-based workforce, and many schools in recent years have focused on increasing the size and number of graduates from their STEM programs. In the state of Kansas, an Engineering initiative in 2011 added 10½ million dollars per year to the three state universities with Engineering programs (i.e., 3½ million dollars per year to each university) in order to increase Engineering graduation numbers by about 60% over ten years.[3] Myose *et al.*[4] discusses the success achieved thus far by the three public universities in Kansas that has Engineering degree programs.

One obstacle to increasing Engineering graduation numbers is student retention. Shuman *et al.*[5] notes that "roughly fifty percent of the students who begin in Engineering leave the field before receiving their Engineering degree" and that "typically half of this attrition occurs during the first year." In the junior and senior years, the number of students leaving Engineering majors drastically decreases, with French *et al.*[6] from Purdue University stating that "about three percent of students leave the engineering program from junior to senior year." Although numbers will vary from university to university, this means that student attrition is likely to still be relatively high in sophomore-level Engineering courses as it is in the freshman year.

Although students may encounter many challenging courses during their academic career, one of the early hurdles is Statics, which is typically taken during the first semester of the sophomore year. Statics is a core class taken by all Engineering students at Wichita State University (WSU) aside from the recent exception of Computer Engineering and Industrial Engineering. The course is taught by a number of different instructors at WSU, and each instructor has their own teaching style, which varies between instructors from traditional lectures to a hybrid style with videotaped lectures and in-class examples of problem solving. Although most Engineering majors require the course, each major has a different definition of what constitutes a passing grade in Statics. Aerospace, Biomedical, Manufacturing, and Mechanical Engineering majors must pass the course with a grade of C, which is equivalent to a grade point of 2.0, because Statics is a prerequisite for subsequent courses taken in these majors. In contrast, Electrical Engineering students can pass the course with a lower grade of D-, which is equivalent to a 0.7 grade point because Statics is not a prerequisite for future courses in Electrical Engineering. Despite different specifications for passing Statics, all students must maintain a 2.0 overall grade point average (GPA) at WSU.

To simplify the initial analysis, if passing is defined to be a grade of C- or above for all Engineering majors who take Statics, about 65% of approximately 750 students passed Statics at WSU according to a recent 2014 study.[7] In the case of the first author, who applied a hybrid structure to his Statics courses, he has had a pass rate of approximately 66% based on a subset of the overall dataset of around 350 students in nine sections. The pass rate for the hybrid class compares well with the rate for the overall dataset, which is consistent with the results of Thomas *et al.*[8], who showed that overall student performance remained constant regardless of the method of instruction used. It is of note that both pass rates for WSU listed above are marginally higher than the pass rate for Statics of 56% at California State Polytechnic University in Pomona during the mid-2000s[9] and 61% at University of Texas – Pan American in the late 2000s to early 2010s[10].

This paper is motivated by a desire to obtain a benchmark for student performance throughout the semester for a hybrid Statics class. This benchmark will allow for instructors of hybrid-style Statics courses to objectively determine the effects of any interventions made to improve student success. First, the development of the hybrid course by the first author will be described along with its advantages, followed by discussion of the topical structure of Statics and results for student performance on individual exams during the semester. A benchmark for student performance then will be generated using cumulative exam averages, and the potential for students to pass Statics despite relatively poor performance prior to the final exam will be examined.

Hybrid Course Format and Development

The topical coverage in Statics is wide-ranging, similar to a survey course, and is relatively fast-paced. Myose *et al.*[7] found evidence suggesting that many students who found freshman courses such as Calculus-based Physics to be fairly easy find Statics to be much more difficult, as reflected in their Statics grades that often were one or more letter grades lower than their Calculus-based Physics grades. These factors motivated the first author to video tape his Statics course so that students could go over difficult concepts multiple times by pausing and rewinding the videos. Another motivator was that the hybrid-style course allowed more classroom time dedicated to examples and review. The creation of the online material also dovetailed with the habits of the current generation of students, who increasingly desire study material to be accessible anytime, anywhere.

Traditional classroom lectures consisting of concept development followed by three example problems were recorded in the fall of 2009. The required equipment for recording consisted of a pen-enabled laptop, Microsoft OneNote software for writing and drawing, TechSmith's Camtasia Studio software for screen capture, a USB microphone on a stand, and a video projector to enable students to view the notes during the initial taping of the lectures in the classroom. Several different types of microphones had been tried with varying results before a USB microphone on a stand was determined to be the best option since it picked up the minimal amount of environmental background noise. The setup and breakdown of equipment at the beginning and end of each class, respectively, added a total of 20 to 30 minutes of effort on the instructor's part for each class period. Post-processing the videos and uploading those files to the class's Blackboard Learn™ webpage added an additional 15 to 30 minutes of effort for each lecture. However, once the classroom lectures had been recorded, post-processed, and uploaded to the Blackboard website, subsequent offerings of a hybrid course did not require significant time-consuming alterations to the online content, with the exception of a few topics that required materials to be edited or rerecorded to correct errors.

Starting in the spring of 2010, the first author offered his Statics course as a hybrid course, in which students could download videos from the class Blackboard webpage for viewing on their own devices at any time, and the instructor solved additional examples during the in–class meetings. Although the university also has a site license for Panapto screen recording software, which allows for videos to be streamed directly from a website, one advantage of having the students download the videos from Blackboard is the reduced likelihood of videos becoming inaccessible because of a website outage. During the initial hybrid Statics course offering by the first author, a critical outage did occur a few days prior to a scheduled exam. Students complained that because they could not access the videos, they could not properly prepare for the exam, which resulted in the exam being rescheduled. In response to this incident, the first author now encourages students to download the video files on their local computer in advance and has placed copies of the video files on DVD discs in the reserve section of the university library as an additional method of offline viewing. However, because the videos are downloaded to local computers and viewed offline, statistical information on the use of these videos by students cannot be obtained via Blackboard.

From the instructor's standpoint, the primary advantage of offering the course in a hybrid format is the ability to increase the number of worked example problems to which students are exposed. When a course is offered in a traditional lecture format, there is limited time available to solve example problems in class. After concept introduction and development, only two to three problems can be covered in each lesson. In contrast, videos for three solved example problems are available to students online, and another problem is worked during class time for each lesson in the hybrid format. In addition, time is available for dedicated review days before exams in the hybrid format where, depending on class length, three to four more examples can be solved in preparation for the upcoming exam.

From an assessment standpoint, another advantage of the hybrid format is the capacity to increase the number of exams since a large part of lectures are covered offline in a hybrid class, leaving more class time available. During the regular 16-week semester, courses are offered either as a 50-minute class that meets three days a week or a 75-minute class that meets twice a week, whereas in the 8-week summer term, classes meet for 60 minutes five days a week. Most Statics instructors at WSU have three or four exams throughout the semester as well as a prerequisite test and a comprehensive final exam. In the first author's hybrid course, seven exams plus a prerequisite test and a comprehensive final exam are administered in 50-minute Statics classes, while 60- and 75-minute classes have only six exams throughout the semester along with a prerequisite test and a comprehensive final exam. By increasing the number of assessments in the class, each exam becomes worth a smaller fraction of the semester grade than the three to four major exams given in a regular lecture class. As a result, students in the hybrid class have the potential to recover from a poor exam more easily than those who do unsatisfactorily on an exam in a traditional format class. Further details about the topical structure of the first author's hybrid Statics course as related to the six to seven exams throughout the semester and student performance on individual exams are discussed in the next section.

Hybrid Statics Course Topical Coverage and Exam-by-Exam Performance

The topical coverage of the Statics course at WSU follows the textbook for the course, *Engineering Mechanics – Statics* by R.C. Hibbeler. Table 1 presents a list of topics covered on each exam in the first author's hybrid course and the week in which the exam is typically given. In addition to the exams in Table 1, students take a prerequisite test and a comprehensive final exam in Statics. The prerequisite test, referred to hereafter as the pre-test, covers Physics and Calculus material and is administered at the beginning of the second week to gauge incoming student capability and knowledge. The final exam is given at the end of the course during the 16th week dedicated to final exams in a regular semester or the last two days of class for an 8-week summer session.

Table 1 indicates that the 50-minute class covers only a few topics on each exam specified in terms of the number of lessons: three on Exams 2 and 6, four on Exams 1, 3, and 5, and five on Exams 4 and 7. Each exam in the 50-minute class has three problems, which are very similar to problems that the students have seen covered in videos, class, the textbook, or assigned problems with solutions available online. The 60- and 75-minute class topic coverage for each exam also is limited: four in Exams 2 and 4 and five in Exams 1, 3, 5, and 6. The exams given in these types of sections have four calculation-based problems per exam, and the 75-minute class has an additional set of concept questions, as discussed in Myose *et al.*[11]

Figure 1 shows the average exam scores earned by students throughout the semester in the first author's hybrid-format Statics sections. The total dataset consisted of 343 students at the start of the semester from classes taught after 2012 when Statics prerequisite testing began. Of those students, 74 were from two 60-minute summer sections, 117 were from three 75-minute classes and 152 were from four 50-minute classes. To determine the average score for each exam, only students who received a nonzero score on the exam were included in the calculation, which meant that the size of the dataset varies from exam to exam. Although the figure shows when the final exam occurs, the final exam average is not provided because this information is not disclosed to the students.

Table 1 – Statics Exam and Topical Coverage [Abbreviations: Ch for Chapter, L for Lesson, & *con* for continuation of Chapter material]

Week	Exam	50-min Class Topics	75-min (& 60-min) Class Topics	Exam	Week
3	1	Ch 2 – Force Vectors (L 1-4)	Ch 2 – Force Vectors (L 1-5)	1	4
5	2	Ch 2 [*con*] (L 5) Ch 3 – Force Equilibrium (L 6-7)	Ch 3 – Force Equilibrium (L 6-7), Ch 4 – Moments (L 8-9)	2	6
7	3	Ch 4 – Moments (L 8-11)	Ch 4 [*con*] (L10-12), Ch 5 – Rigid Body Equilibrium (L 13-14)	3	8
9	4	Ch 4 [*con*] (L 12), Ch 5 – Rigid Body Equilibrium (L 13-15), Ch 6 – Trusses (L 16)	Ch 5 [*con*] (L 15), Ch 6 – Trusses & Frames (L 16-18)	4	10
10		*Last Day for Withdrawal*	*Last Day for Withdrawal*		10
11	5	Ch 6 [*con*] (L 17 & 18 on Frames) Ch 7 – Internal Forces (L 19-20)	Ch 7 – Internal Forces (L 19-21) Ch 8 – Friction (L 22-23)	5	12
13	6	Ch 7 [*con*] (L 21 on diagrams) Ch 8 – Friction (L 22-23)	Ch 9 & 10 – Section Properties (L 24-28)	6	15
15	7	Ch 9 & 10 – Section Properties (L 24-28)			

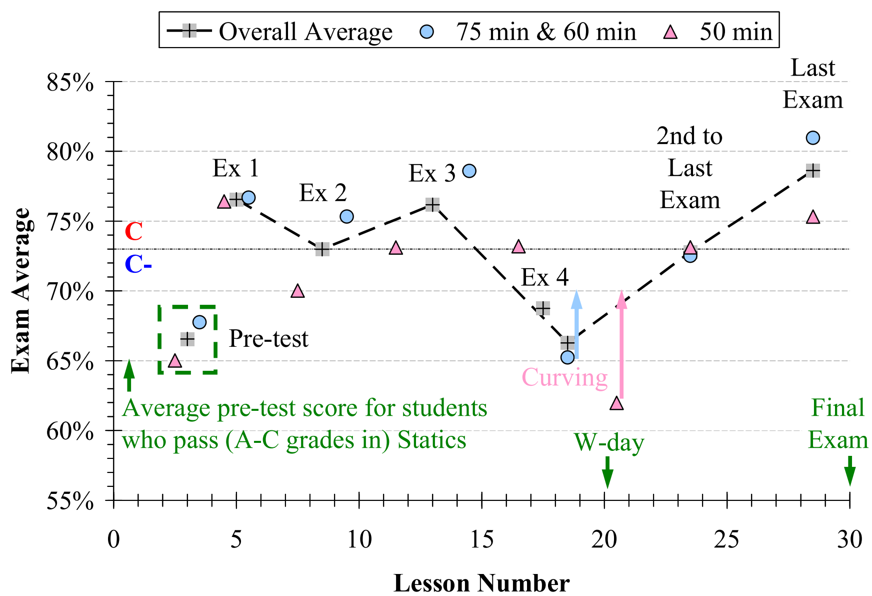

Figure 1 – Averages of Exams Given During the Semester.

The overall average of all sections for each exam are shown in Figure 1 by grey squares, and the overall trend in the averages is depicted by the dashed line. Although the topical coverage begins to diverge after Exam 1 between the 50-minute classes and the 60/75-minute classes, the overall average for each exam, with the exception of Exam 4, was calculated using the data for all sections regardless of slight differences in topical coverage. For Exam 4, the overall average was found two different ways, as shown by two different grey squares at lessons 17 and 19. In the first approach, represented by the grey square at lesson 17, the average of Exam 4 for the 60- and 75-minute classes was simply averaged with that of Exam 4 for the 50-minute class. The second approach, noted by the grey square at lesson 19, involved first averaging the exam averages of Exams 4 and 5 for the 50-minute class and then averaging this value with the exam average for Exam 4 of the 60- and 75-minute classes. Both approaches resulted in an average that was very close to the overall trend given by the dashed line.

In Figure 1, the exam averages for the 50- and 60/75-minute classes also are shown separately as pink triangles and blue circles, respectively. In general, the exam averages of the 50-minute class were lower than the exam averages of the 60- and 75-minute classes. Only the average for Exam 4 was higher; however, this exam covered different material in the 50-minute classes, making a direct comparison between sections not accurate for this exam. Myose *et al.*[11] analyzed this disparity in performance between the two types of sections in depth, concluding that the lower pre-test scores of students in the 50-minute indicated weak capability and prerequisite knowledge, which in turn lead to lower end-of-semester GPAs.

One date of particular interest during the course of the semester is the last day to withdraw from the course with a grade of W, which occurs at the end of the 10th week for a regular semester class as shown in Figure 1. At WSU, students are classified as having attempted a course if they receive a grade of A through F, and courses can be attempted up to three times without having to seek special permission. A grade of W does not count as an attempt at taking the course nor does it factor into the calculation of GPA. About 11% of the students had Ws in Figure 1. Although a grade of W has fewer consequences than a grade of F, some students remain in the course even though they are flunking instead of withdrawing from the class. Often, students choose this path in order to maintain full time status for financial aid or immigration status purposes. In the latter half of the course, a number of these students stop coming to class and do not even take the exams.

One should be careful in drawing too many conclusions from Figure 1 since student characteristics of the dataset for each exam are masked by the averages and are not readily apparent. The size of the dataset for each exam, and thus the type of students the dataset encompasses, changes as students withdraw from the class or stop attending. For example, Exam 1 consists of topical material that has already been covered in Physics and Math, though some extensions of this material are made. Because the material on Exam 1 is generally review and fairly easy, many students perform well on it. However, the data in Figure 1 indicates that the average in Exam 1 is lower than that for the last exam, which is comprised of completely new material. Part of the reason that the average is lower on an exam with mostly review material is that the dataset for first exam includes students who are less capable and do poorly. By the last exam before the final in the course, these students have either withdrawn or stopped attending and are therefore not included in the dataset for the last exam. Compared to the first exam, there are approximately 13% fewer students taking the last exam. If the students who did poorly on Exam 1 and consequently withdrew by the 10th week or stopped attending had taken the last exam, that average would very likely be much lower than the average shown in Figure 1.

Cumulative Student Performance Throughout the Hybrid-format Course

In order to objectively evaluate the effect of any alterations to teaching method or of attempts at early intervention in the class, a benchmark for current student performance must be developed. A number of different studies have created benchmarks by correlating concept inventory tests, similar to the WSU pre-test described earlier, to various metrics such as exams given during the semester, the final exam, or the semester grade. Steif and Hansen[12] correlated their Statics concept inventory in this manner, providing correlation coefficients. Huang and Fang correlated a number of variables, including student GPA, grades in prerequisite courses, exams given during the semester, final exams, and the semester grade to generate predictive models for student performance in Dynamics.[13] Subsequently, they used their models to predict student performance in successive offerings of the Dynamics course.[14] Myose *et al.*[11] correlated the pre-test scores with the end-of-semester grade to measure the incoming student capability and knowledge. The authors did not find any studies in the literature discussing cumulative student performance over the course of the semester, which suggests that the following benchmark created for a hybrid Statics course is somewhat unique.

The first part of the development of a cumulative performance benchmark entailed the calculation of exam averages for Exam 1, Exams 1 and 2 combined, Exams 1 to 4, and all regular exams, excluding the pre-test and the final exam. Exam 4 was chosen as a cutoff point since the withdrawal date occurs soon after Exam 4 is given, and any interventions that might be developed in the future would need to occur prior to this exam. For the analysis, students were divided into two groups: (1) those that pass with grades of A through C, and (2) those that do not pass with grades of C- to F as well as Ws. The combination of both groups was used as a reference. Table 2 presents the results for the cumulative average, the standard deviation, and the number of students for four different subgroups of the semester exams. To obtain the cumulative average for a subset of exams, each student's scores from the exams in that subset were averaged, and then those individual averages were averaged together to get the overall cumulative average. If a student did not take all of the exams in a particular subset, then they were excluded from the analysis of that specific group of exams.

Table 2 – Cumulative Average, *Standard Deviation (SD)* and Number of Students (N)

Group \ Average, *S.D.*, (N)	Exam 1	Exam 1 & 2	Exams 1 to 4	All Regular Exams
Those that pass (A-C)	85.9% *12.7%* (201)	84.6% *9.6%* (200)	83.5% *8.2%* (193)	83.0% *7.7%* (167)*
All students (reference)	76.6% *19.2%* (343)	75.2% *16.5%* (337)	75.5% *14.1%* (304)	76.4% *12.8%* (243)*
Not passing (C- to F & W)	63.5% *19.4%* (142)	61.5% *14.7%* (137)	61.6% *11.1%* (111)	62.0% *9.8%* (76)*

The number of students, N, decreases throughout the semester in Table 2 primarily because 45 students stopped taking exams at various points in the semester but remained enrolled in the course. Another set of 30 students were eliminated from the dataset in the rightmost column when their last exam before the final exam was cancelled in the fall of 2018 due to a Presidential funeral. The remaining 25 students had legitimate excuses for missing exams, and the grade that they received on the final exam replaced their missing exam score in the calculation of their semester grade. However, because they did not take every exam, they were excluded from the average of the cumulative exam scores. For these reasons, the number of students (indicated by *) for the rightmost column of Table 2 is significantly fewer than the starting number for Exam 1.

It is interesting to note from Table 2 that the cumulative averages do not vary significantly over the course of the semester. The largest variation is a decrease of 2.9% from an average of 85.9% in Exam 1 for those students that pass the course. The range of passing grades is from an A to a flat C, and therefore, it is not surprising that the average for this group is a B, which ranges from 83 to 85.9%. The correspondence of the cumulative averages of Exam 1 and all regular exams precisely to the percentage range of a letter grade of B is likely coincidental, though.

While the calculation of the cumulative average using only scores from students who took all of the exams in a particular subset may seem laborious, it is necessary in order to get an accurate benchmark of performance. If the averages for the three subsets of exams in Table 2 were calculated based on the exam averages in Figure 1, the average of Exams 1 and 2 would be 74.9%, the average of Exams 1 to 4 would be 74.1%, and the average of all regular exams would be 74.2%. As the semester progresses, the difference between the straightforward average of exam averages in Figure 1 and the cumulative average in Table 2 grows from 0.3% to 2.2%. By averaging the exam averages in Figure 1, students who did poorly in the beginning of the course but then withdrew effectively continue to be a part of the dataset since their scores affected early exam averages. This logic explains the difference in the two types of averaging and the necessity of using cumulative averaging to measure the performance of students throughout the duration of a course.

Nevertheless, as noted in the previous section, an analysis based solely on averages can obscure certain trends in the data. Earlier in the paper, it was noted that many students performed well on Exam 1; however, the average on Exam 1 of 76.6% for the dataset of all students does not reflect this observation. When details of the distribution of the cumulative averages were considered, the results showed more variance in student performance than the averages over the course of the semester. Figure 2 presents the distributions of the cumulative averages for the same three groupings of students and four exam subsets as Table 2. It can be seen from Figure 2 that over 50% of all students earn grades of As and Bs on Exam 1, which is not reflected in the overall average for Exam 1. In the group of students that pass Statics, almost 50% of the students earn an A on Exam 1; however, over the course of the semester, the number of As decreases while the number of Cs increases. In the group of students that do not pass Statics, the number of As, Bs, and Cs decreases throughout the semester, while the number of Ds increases. These trends are evident in Figure 2, but not in the cumulative averages of Table 2 or the exam average shown in Figure 1. Therefore, more statistics than averages must be used in order to develop an accurate benchmark.

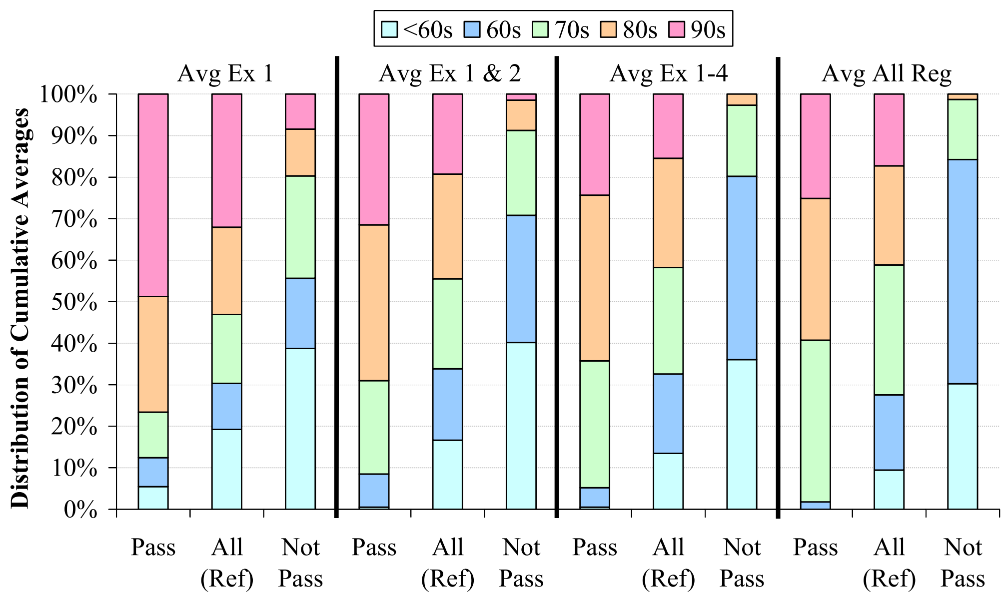

Figure 2 – Distribution of Cumulative Averages: those that pass, all students (reference), and those that do not pass.

In order to find further trends in the data, the reference group of students for each subset of exams was subdivided into grade point levels according to the plus-minus grading system with the exception of Ws, and a least squares fit was applied to cumulative averages at each grade division. Pearson correlation coefficients, shown in Table 3, were used to quantify the variance between the averages for several subsets of exams and the end-of-semester grades. The two leftmost columns of Table 3 contain correlation coefficients between individual exams and the end-of-semester grade, while the remainder of the columns incorporate cumulative averages of exam subsets and the end-of-semester grade. The data for the pre-test and Exam 1 combined column was calculated in a similar manner to the other cumulative averages found earlier in this section.

Table 3– Correlation Between Cumulative Average (or Single Exam Average) and Semester Grade

Pre-test	Exam 1	Pre-test & Exam 1	Exam 1 & 2	Exams 1 to 4	All Regular Exams
0.457	0.628	0.678	0.783	0.883	0.947

The Pearson correlation coefficient ranges between +1 and –1. It is +1 when two quantities are perfectly correlated, 0 when there is no correlation at all, and –1 when an increase in one variable leads directly to a decrease in the second variable. There is less scatter in the data when the Pearson correlation coefficient approaches +/–1, while there is much more scatter when the coefficient nears zero. The cumulative average of the pre-test and Exam 1 correlated better with the semester grade than those exams individually did. The correlation increased substantially from a moderate level with the pre-test at the start of the semester to a near-perfect level before the final exam. This level of correlation between the cumulative average of all regular exams and the end-of-semester grade indicates that only a few students are able to change grade levels with the final exam. By the withdrawal date, which occurs after Exam 4, the Pearson correlation coefficient is 0.883 between the cumulative average of Exams 1 through 4 and the semester grade. This relatively high level of correlation suggests that decisions about whether to complete the course or withdraw based on a student's cumulative average over four exams would be reasonably accurate.

Figures 3, 4, and 5 present the least squares fits corresponding to the correlation coefficients in Table 3 for various subsets of exams The cumulative averages at each grade level are shown as square symbols, and standard deviation bars show the variance of the data one standard deviation above and below each average. It is important to note that the Pearson correlation coefficients in Table 3 represent the variance between the data point at a particular grade level and the least squares fit line, which differs from the standard deviation bars on the plots that represent the variance in the original data used to generate the cumulative averages.

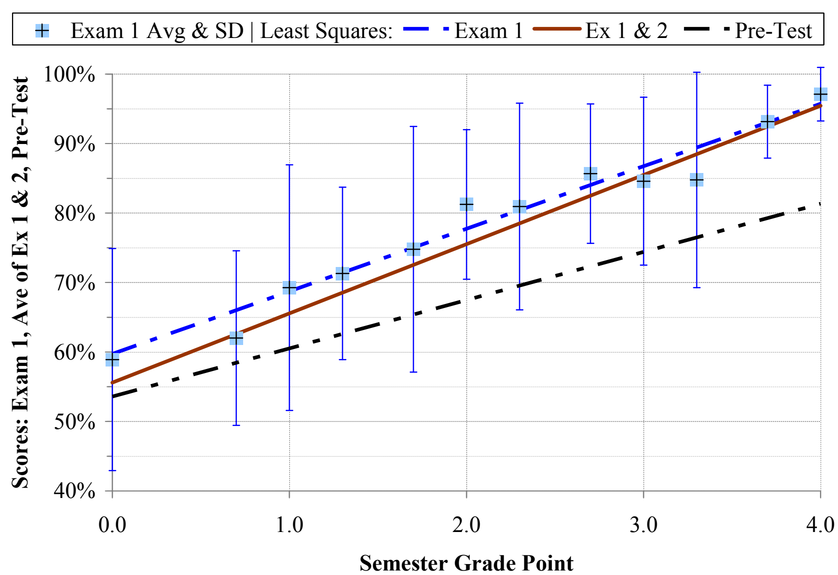

Figure 3 – Pre-test, Exam 1, and Exam 1 & 2 Cumulative Averages as a Function of Semester Grade.

Figure 3 depicts the least squares fit lines for the pre-test, Exam 1, and Exams 1 and 2 combined, along with the averages and standard deviation for Exam 1. The average scores associated with each grade level for Exam 1 have high levels of variance, as indicated by the large standard deviation bars. From this plot, it can be seen that if the pre-test results were directly converted to semester grade, the pre-test would be considered more difficult than the rest of the Statics course. For example, a pre-test score of 67% and 81% would correspond respectively to grades of C and A according to the least squares fit line for the pre-test. Conversely, Exam 1 is relatively easy, testing students over topical material covered in previous courses, and as a result, those who earn grades of Cs and As in the course earned scores on the exam of 78% and 96%, respectively, based on the least squares fit line for that exam. Since Exam 2 covers new material, it is a bit more difficult, which is reflected in the fact that the least squares fit line for the cumulative average of the Exams 1 and 2 combined is below the line for Exam 1. However, this fit still is located near the upper end of the score range for each grade level. This suggests that the more difficult topical material, such as frames in Chapter 6, that reduces the cumulative average occurs later in the semester.

Figure 4 shows the cumulative averages of Exams 1 to 4 at each grade level and the corresponding least squares fit line, along with the least squares fit lines from Figure 3 for reference. By Exam 4, the least squares fit line for the cumulative average over Exams 1 to 4 has moved closer to the lower end of the score range for each grade level. Concurrently, there is reduced variance in the scores associated with each grade level as indicated by smaller standard deviation bars.

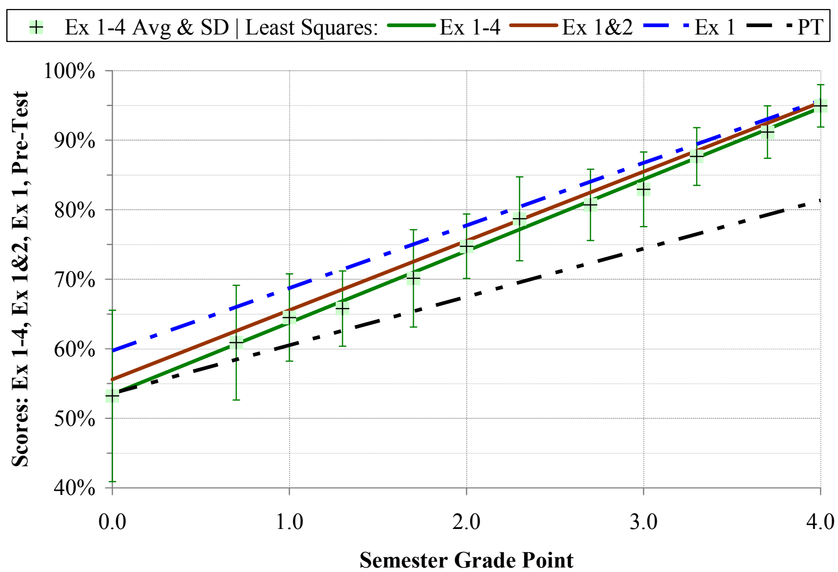

Figure 4 – Pre-test, Exam 1, Exam 1 & 2, and Exams 1-4 Cumulative Averages as a Function of Semester Grade.

Figure 5 similarly presents the cumulative averages for each grade level and the corresponding least squares fit line for the dataset of all regular exams, excluding the pre-test and the final exam. Least squares fits from Figures 3 and 4 again are provided for reference. In Figure 5, the standard deviation bars have decreased significantly in size, and most standard deviations are about 3% in height, which is the typical range for a grade level. This result is not surprising since the Pearson correlation coefficient between the cumulative average of the regular exams and the semester grade is an extremely strong correlation value of 0.947. The least squares fit line for the cumulative average over all regular exams overlaps with the fit for Exams 1 to 4 in the letter grade range of A to C, indicating that little has changed in this region of the data. However, the slight increase in the slope of the fit line for all exams creates a gap between this fit and the fit for Exams 1 to 4 at the lower grade levels of C- to F, illustrating the downward trend of the cumulative average that arises as a result of more challenging material being covered in the latter portion of the course.

Having analyzed general class performance for trends, the potential for students to pass Statics despite relatively poor performance prior to the final exam will be examined. The lower end of each standard deviation bar in Figure 5 is often below the score range associated with a particular grade level. For example, the typical student who earns a C in Statics has a cumulative average of 74.5% on all regular exams with a standard deviation of 2.9%. This deviation value would make the lower bound on the range of scores corresponding to a C at 71.6% instead of the 73% that is necessary to receive a C, suggesting that students can overcome small deficiencies in their regular exam cumulative average with the final exam. Furthermore, individual students exist at a grade level of C who are outliers at more than one standard deviation below the cumulative average score. These outliers show that it is possible for students to have much lower scores than the cumulative average for all regular exams and still perform well enough on the final exam to earn a C for their semester grade. However, there is a limit to the lower end of the score range, beyond which it is not possible for a student to earn a C despite a good score on the final exam. No student with a cumulative average below 60% for all regular exams earned a semester grade of C. With the final exam worth 22% of the semester grade, it is not mathematically possible to earn a 73% for a C if a student has a cumulative average for all regular exams of 59.9%.

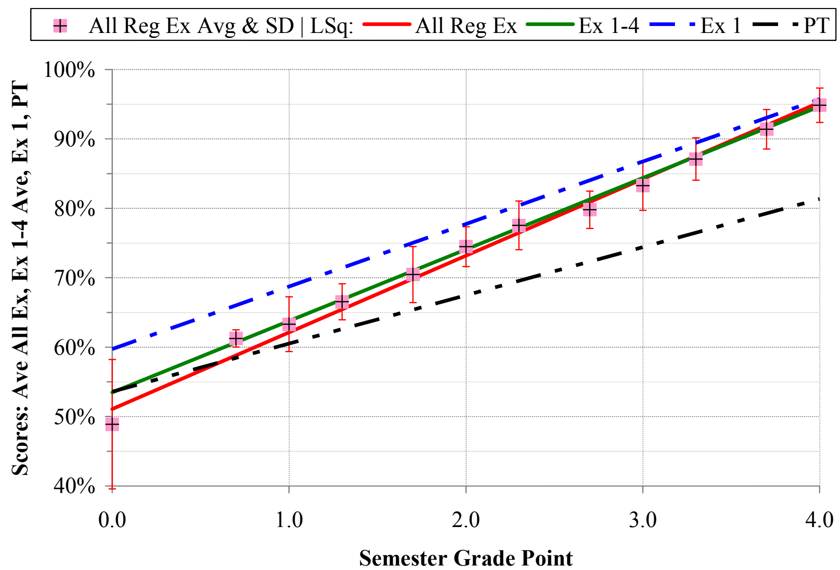

Figure 5 – Pre-test (PT), Exam 1, Exam 1-4, and All Regular Exam Averages as a Function of Semester Grade.

Even though some students are able to change their semester grade by their performance on the final exam, on the whole, student outcomes are fairly set after Exam 4 as previously noted, and any interventions to improve student success would need to be implemented earlier in the Statics course. A literature survey indicates that there are a number of different possibilities for intervention in Statics. Burkhardt[15] reviews a variety of these different techniques including increased contact time, supplemental instruction, active learning, project-based learning, and one-on-one tutoring. He notes that the effectiveness of any given intervention is highly dependent on the appropriate implementation of that technique. As a result, Burkhardt concludes that there is a need for high-quality assessment of intervention techniques. The results of the current study should provide a benchmark for the evaluation of the efficacy of any intervention techniques applied in a hybrid Statics course at WSU.

Summary

Student performance characteristics in a hybrid Engineering Statics class were investigated in this study. Although cumulative averages did not vary much over the course of the semester, the distribution of scores varied significantly. An examination of students divided into grade levels found that decreasing amounts of variance in cumulative exam averages existed at each grade level as the semester progressed. By the withdrawal date, the cumulative exam average could be used with relatively good confidence to predict end-of-semester grades. While students can and do improve their end-of-semester grades with good performances on the final exam, there is a limit to the amount of improvement that is possible after the completion of the regular semester exams. These results help provide a benchmark that can be used in the future for comparison when interventions are made to affect student success in Statics at WSU.

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