10-2020

# A Hybrid Mechanics of Materials Course Part 1: Evolution of the Course to Improve Student Performance and Retention

Roy Y. Myose

Foo Ngai Kok

Elizabeth Rollins

Paper ID #32152

# A Hybrid Mechanics of Materials Course Part 1: Evolution of the Course to Improve Student Performance and Retention

**Dr. Roy Y. Myose, Wichita State University**

Roy Myose is a Professor of Aerospace Engineering at Wichita State University.

**Dr. Foo Ngai Kok**

Foo Kok is an Assistant Professor of Aeronautics and Astronautics Engineering at the University of Southampton Malaysia.

**Elizabeth Rollins**

# A Hybrid Mechanics of Materials Course
# Part 1: Evolution of the Course to Improve Student Performance and Retention

**Roy Myose**
Aerospace Engineering Department, Wichita State University, Wichita, KS 67260-0042
**Foo Ngai Kok**
Dept. of Aeronautics & Astronautics, Univ. of Southampton Malaysia, Johor, 79200, Malaysia
**and Elizabeth Rollins**
Aerospace Engineering Department, Wichita State University, Wichita, KS 67260-0042

## Abstract

A hybrid Mechanics of Materials course consisting of recorded lecture videos and face-to-face class meetings was developed. Initial offerings of the hybrid course resulted in a drop in average student performance by – 0.18 grade points as well as a reduction in the student pass rate of 3%. Over time, average student performance in the course improved; however, the student pass rate remained relatively constant. A number of ad hoc internal studies by the hybrid course instructors were conducted to attempt to determine the factors contributing to the reduction in the student pass rate. A test over prerequisite Statics and Calculus material was developed and incorporated into the course in order to gauge incoming student capability and knowledge. Results of this pre-test provided a baseline measure so that the effect of various changes to the hybrid course could be objectively measured independent of differences in student capability. Internal studies suggested that a lack of student engagement as manifested by poor attendance in face-to-face class attendance contributed to poor performance and reduced student retention. The hybrid course policy was changed by incorporating a one letter grade penalty for students who did not have good attendance. This resulted in an improvement in average performance by 0.18 grade points and an increase in student retention by 12.5% compared to the optional-attendance hybrid course.

## Introduction

In today's increasingly technological world, the availability of a highly skilled Science, Technology, Engineering, and Math (STEM) workforce determines whether a nation can remain economically 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] For this reason, STEM jobs are in high demand, and wages for STEM occupations are more than double that for non-STEM occupations according the U.S. Bureau of Labor Statistics.[2] Such wage differentials attract many students into the STEM fields, but their retention and ultimately their graduation with a STEM degree are not guaranteed. "Some policymakers have targeted reducing STEM attrition in college" as an efficient way "to produce the STEM professionals that the nation needs."[3] Consequently, universities have become increasingly concerned about student retention and bottleneck courses that prevent students from moving at a steady pace toward degree completion.

One such bottleneck occurs in the sophomore year for engineering majors in the Mechanics courses. At Wichita State University, most engineering majors must pass the first Engineering Mechanics course, Statics, before graduating with an engineering degree. Based on a criteria of an A, B, or C letter grade corresponding to a passing grade in a course, the overall pass rate in Statics at Wichita State for ~750 students was 64% according to a 2014 report.[4] This dataset included 175 students in the first author's Statics sections that were taught in a hybrid format using both lecture videos and face-to-face meetings with all exams conducted in a face-to-face format. The students that took the first author's hybrid format Statics course had a very similar pass rate of about 66%

compared with the pass rate for all Statics students. This result was encouraging since the format of the delivery of the course material did not appear to be a significant factor in student retention for the Statics course.

As an increasing number of courses are being taught in a hybrid or fully online format during this present-day health crisis, ensuring that there are no significant outcomes differences between various methods of content delivery is critical in order to maintain and eventually improve the student retention rate. In Mechanics of Materials, Thomas *et al.*[5] examined a variety of class formats, such as a traditional lecture style with or without the addition of online videos, a fully online format without face-to-face meetings, and a flipped class utilizing online videos outside of class and active learning during face-to-face meetings. Overall student performance was similar, irrespective of class format. However, the comparisons between styles were made with different students taking different versions of the course and not the same students taking different versions of the course. A companion paper by Myose and Rollins[6] considers the difference in performance when a hybrid format class is suddenly changed to fully online format for a single group of students.

Based on the first author's experience with the creation of his hybrid format Statics class and the report by Thomas *et al.*[5] for Mechanics of Materials, there was an expectation on the part of the first author that student performance should not be significantly affected following the conversion of an existing Mechanics of Materials course into a hybrid format. However, this did not turn out to be the case when the first author converted his Mechanics of Materials course to hybrid format. The change in student performance with the move to a hybrid format motivated a study to determine the factors affecting student retention in a hybrid Mechanics of Materials course.

## Hybrid Course Format

The first author has taught over 1200 students in 30 different sections of Mechanics of Materials over a period of a quarter century. The course has evolved over time with respect to course content, pedagogical methods, and textbooks. One of the largest changes was the development of a hybrid offering of Mechanics of Materials in which students studied on their own prior to attending face-to-face problem solving sessions. In the hybrid course offering, students were supposed to study on their own outside of class by reading the textbook, watching the lectures and example problems videos that had been posted to the Blackboard Learn™ course site, and solving homework practice problems before coming to class for a short review and the demonstration of the solution of an additional example problem during face-to-face meetings.

In the summer of 2007, lectures consisting of concept development and three example problems were recorded using a pen-enabled laptop, Microsoft OneNote software for writing and drawing, and TechSmith's Camtasia Studio software for screen and audio recording. Additionally, the first author created a fixed set of problems for each lesson to use as classroom examples, homework practice problems, and exam problems. Knowing the relative pervasiveness of solutions manuals and the unfairness that can result from inequitable access, the handwritten solutions to practice problems were made available on the Blackboard Learn™ course site to all students. Students are strongly encouraged to practice these problems in preparation for the exams. The first author does not collect homework for a grade, instead choosing to assess students with exams relatively frequently.

Since the spring of 2009, the first author's classes have been offered in hybrid format. Thirty different lessons from R. C. Hibbeler's *Mechanics of Materials* textbook chapters 1 through 13 are covered during the course of a semester. In 50-minute classes that meet face-to-face three times a week, students are assessed through six exams and a comprehensive final exam. Each regular exam has three problems, which typically involve drawing a free body diagram, writing equations, and then solving for numerical answers with appropriate units. During the summer when the course meets for 60 minutes each day, students are evaluated through five exams that are comprised of four problems each and a comprehensive final exam. In 75-minute classes that meet face-to-face twice a week, students are assessed through five exams and a comprehensive final. Each regular exam consists of four problems as well as four multiple-choice questions that test a student's conceptual knowledge and awareness of appropriate units or notation for a standard term. A conceptual knowledge question might ask a student to identify where the maximum principal stress is located on Mohr's circle, while a question on awareness of units and notation might require a student to identify the Greek letter used for normal stress or shear strain. Myose *et al.* 2019a[7] found that student performance in multiple-choice type concept questions was similar to the performance in longer numerical calculation problems in both sophomore year Statics and junior year Propulsion courses. Table 1 shows the topical coverage of each exam in 50-minute classes on the left-hand column while the right-hand column shows the topical coverage of each exam in 60- and 75-minute classes. Since the number of problems that can be reasonably asked during a 50-minute exam is different than for a 75-minute exam, the course structure and number of exams is different.

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

<table>
<tr><th>Wk</th><th>Ex</th><th>50-min Class Topics</th><th>75-min (& 60-min) Class Topics</th><th>Ex</th><th>Wk</th></tr>
<tr><td>2</td><td>Pre-test</td><td>Prerequisite Assessment Test over Statics & Calculus</td><td>Prerequisite Assessment Test over Statics & Calculus</td><td>Pre-test</td><td>2</td></tr>
<tr><td>4</td><td>1</td><td>Ch 1 Stress (L 1-3), Ch 2 Strain (L 4), Ch 3 Material Properties (L 5)</td><td>Ch 1 Stress (L 1-3), Ch 2 Strain (L 4), Ch 3 Material Properties (L 5-6)</td><td>1</td><td>4</td></tr>
<tr><td>6</td><td>2</td><td>Ch 3 [con] (L 6)<br>Ch 4 Axial Load (L 7-9)</td><td>Ch 4 Axial Load (L 7-9),<br>Ch 5 Torsion (L 10-11)</td><td>2</td><td>6</td></tr>
<tr><td>8</td><td>3</td><td>Ch 5 Torsion (L 10-13)</td><td rowspan="2">Ch 5 [con] (L 12-13),<br>Ch 6 Bending (L 14-15),<br>Ch 7 Transverse Shear (L 16)</td><td rowspan="2">3</td><td rowspan="2">9</td></tr>
<tr><td>10</td><td>4</td><td>Ch 6 Bending (L 14-15),<br>Ch 7 Transverse Shear (L 16-17)</td></tr>
<tr><td>10</td><td></td><td>Last Day for Withdrawal</td><td>Last Day for Withdrawal</td><td></td><td>10</td></tr>
<tr><td>12</td><td>5</td><td>Ch 8 Combined Loadings (L 18-19),<br>Ch 9 Stress Transformation (L 20-22)</td><td>Ch 7 [con] (L 17),<br>Ch 8 Combined Loadings (L 18-19),<br>Ch 9 Stress Transformation (L 20-22)</td><td>4</td><td>12</td></tr>
<tr><td>14</td><td>6</td><td>Ch 10 Strain Transformation (L 23),<br>Ch 12 Beam Deflection (L 24-26)</td><td>Ch 10 Strain Transformation (L 23),<br>Ch 12 Beam Deflection (L 24-28)</td><td>5</td><td>14</td></tr>
<tr><td>16</td><td>Final</td><td>Ch 12 [con] (L 27-28),<br>Ch 4,5,6 Stress Concentration (L 29),<br>Ch 13 Buckling (L 30)</td><td>Ch 4,5,6 Stress Concentration (L29),<br>Ch13 Buckling (L30)</td><td>Final</td><td>16</td></tr>
</table>

## Student Performance in a Hybrid Mechanics of Materials Course

In their Mechanics of Materials course, Thomas *et al.*[5] found that *overall* student performance was similar, irrespective of class format. However, this comparison was made with different groups of students. One question that arises is whether the different groups of students were different in terms of incoming capability and prerequisite knowledge. To address this issue, a pre-test over prerequisite Statics and Calculus material is given to students at Wichita State during the second week of the course, as noted in Table 1. This pre-test provides a measure of the incoming student capability and knowledge. It has been administered in Mechanics of Materials classes at Wichita State University since the fall of 2015 to a total of 692 students in 19 sections taught by three different instructors teaching in the traditional face-to-face format as well as in a hybrid format.

The Pearson correlation coefficient between the beginning of semester pre-test and the end-of-semester grade was calculated to determine the degree of relation between the two quantities. 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 entire dataset of 692 students had a moderate Pearson correlation coefficient value of +0.52. Based on a least squares fit of the entire dataset, Smith *et al.*[8] found that the average student who passes the course has a pre-test score of about 70%. However, the moderate Pearson correlation coefficient value of +0.52 indicates that there is a large amount of scatter in the data, as evidenced by the fact that the standard deviation in the pre-test score for students who received an end-of-semester grade of C is 15%.

In the group of 692 students who took the pre-test, 521 students in 13 different sections were from the first author's hybrid course. The Pearson correlation coefficient for the students who only enrolled in the hybrid course was +0.53, which makes sense since the students in the hybrid section constituted the majority of the entire dataset. Of the 521 students in the hybrid course, 461 students took all of the exams and the comprehensive final. Out of the 461 students, 30 students were from one section of a 60-minute summer class, 316 students were from eight sections of 75-minute classes, and 115 students were from four sections of 50-minute classes.

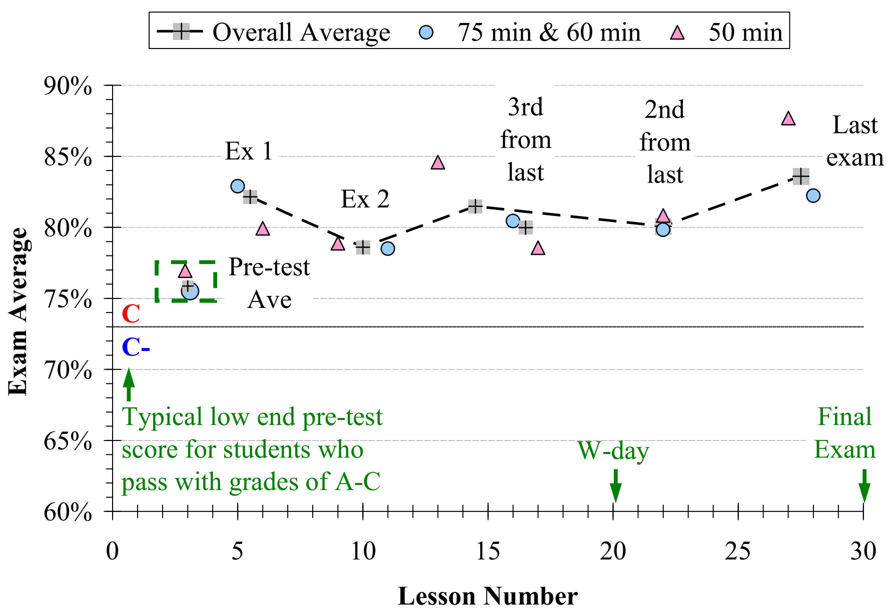


Figure 1 – Exam Averages During the Semester.

Figure 1 shows the average exam scores earned by students in the hybrid course throughout the semester. 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. The overall average of all hybrid 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 was calculated using the data for all sections regardless of slight differences in topical coverage. For Exam 3, the overall average was found two different ways, as shown by two different grey squares at lessons 15 and 17. In the first approach, represented by the grey square at lesson 15, the average of Exam 3 for the 60/75-minute classes was averaged with that of Exam 3 for the 50-minute class. The second approach, defined by the grey square at lesson 17, combined the average of Exam 3 for the 60/75-minute classes with the average of Exam 4 for the 50-minute class. Both approaches resulted in an average that was very close to the overall trend given by the dashed line. The overall trend in the exam scores was roughly constant at about 82% to within about +/- 2% over the course of the semester.

In Figure 1, the exam averages for the 50- and 60/75-minute classes are shown separately as pink triangles and blue circles, respectively. Some exam averages for the 50-minute class, particularly those on Exams 3 and 6, were well above the overall trend. This difference may be partly due to the fact that the topical coverage on those exams for the 50-minute class differs from the coverage on the exams for the 60/75-minute class. Myose et al. 2019a[7] examined whether a difference in exam duration and format affected student performance in a hybrid Statics class. The conclusion was that incoming student capability measured by the pre-test was a stronger indicator of student performance than exam duration, which concurs with the data shown in Figure 1. The average pre-test score for the 50-minute class was slightly higher than that for the 60/75-minute class, which indicated that students in the 50-minute class were likely to have higher capability and prerequisite knowledge that may have led to the increased exam averages on Exams 3 and 6.

Pearson correlation coefficients shown in Table 2 were used to quantify the variance between different exams and the end-of-semester grade. The two leftmost columns of Table 2 contain correlation coefficients between individual exams and the end-of-semester grade, while the remainder of the columns consists of the correlation coefficients between averages of several exams and the end-of-semester grade. It is notable that the combined average of the pre-test and Exam 1 did not correlate with the semester grade as well as Exam 1 by itself. However, the correlation increased substantially from a moderate level with the pre-test to a near-perfect level when the average of all exams taken before the comprehensive final was considered. This level of correlation between the average of all regular exams and the end-of-semester grade indicates that only a few students were able to change grade levels with the final.

Table 2 – Correlation Between Average of Several Exams (or Single Exam) and Semester Grade

| Pre-test | Exam 1 | Pre-test & Exam 1 | First Half Exams | Last Half Exams Only | All Regular Exams |
|---|---|---|---|---|---|
| 0.528 | 0.686 | 0.643 | 0.830 | 0.898 | 0.957 |

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 15-week semester class as shown in Figure 1. A grade of W does not count as an attempt at taking the course nor does it factor into the calculation of grade point average (GPA). By the withdrawal date, the Pearson correlation coefficient between the average of exams completed at that point and the semester grade was 0.888. This relatively high level of correlation suggests that decisions about whether to complete the course or withdraw based on a student's cumulative average would be reasonably accurate at that point in the semester. Myose *et al.* 2019b[9] observed a similar result when studying the most effective time during the semester for intervention efforts to help improve student grades in a hybrid Statics class since most students' grades were largely determined before the withdrawal date.

Figure 2 presents the least squares fits corresponding to the correlation coefficients between the end-of-semester grade and the average of exams taken during the first and second halves of the semester, which are provided in the fourth and fifth columns of Table 2, respectively. The square symbol represents the average of the exams given during the first half of the course, and the blue standard deviation bars show the variance of the data one standard deviation above and below each average for the first half of the semester's performance. The x-symbol and red bars represent the equivalent values for the second half of the semester's performance. It is important to note that the Pearson correlation coefficients in Table 2 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 averages. It should be noted that the overall number of students involved at 461 is fairly large, but there were less than 20 students that received grades of F, D-, D, and D+. Therefore, the statistical averages at those grade levels is somewhat marginal in quality.

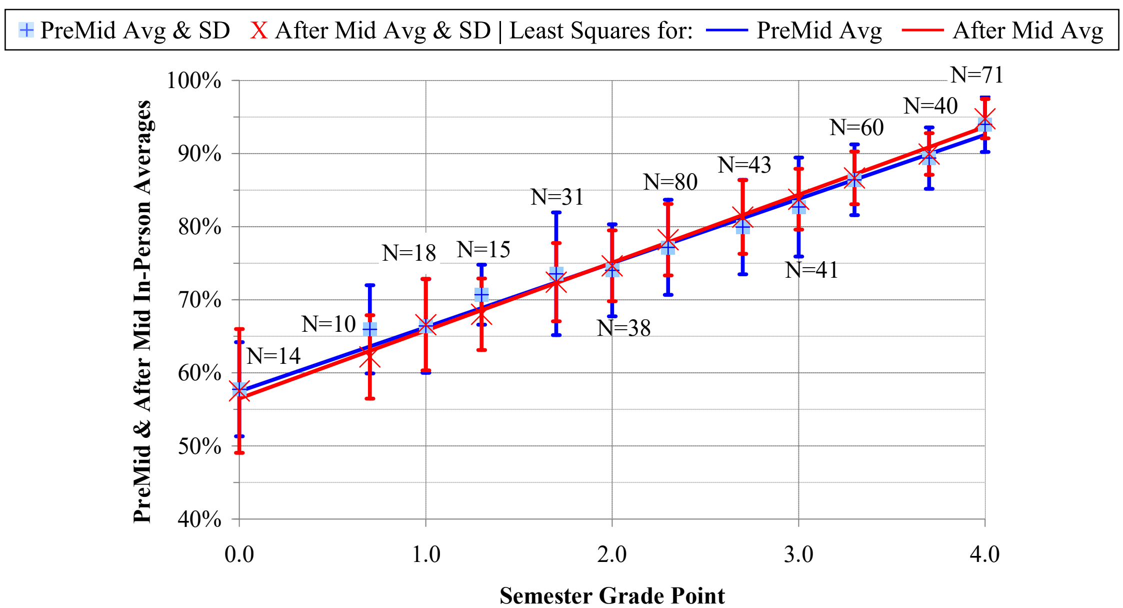


Figure 2 – Exam Averages for the First and Second Half as a Function of Semester Grade.

The least squares fit lines for the first and second halves of the course in Figure 2 appear to be nearly superimposed, suggesting that overall student performance in the first half of the semester is comparable with the performance in the second half of the semester. This observation is consistent with the results shown in Figure 1, where the overall performance remained relatively constant throughout the semester. However, it is clear that the range of averages for each grade point as indicated by the height of the standard deviation bars becomes smaller over the second half of the semester. At the end of the semester once the comprehensive final has been included, the range of scores at each grade naturally narrows further to about +/- 1.5%, which corresponds to the percentage range of 3% associated with each plus/minus grade level.

## Comparison Between Face-to-Face and Hybrid Instruction

Having taught Mechanics of Materials in both a face-to-face and a hybrid method, the first author sought to evaluate the efficacy of the hybrid format. The performance of two sections of face-to-face instruction taught in Summer 2004 and Summer 2006 was compared with the initial hybrid offerings in Spring and Summer 2009. When the Mechanics of Materials course was taught in the traditional face-to-face format, 69.8% of the 43 students in two sections with an average class size of 22 passed with a grade of A, B, or C. When the course was initially taught in hybrid format, 66.7% of the 93 students in two sections with an average class size of 47 passed with a grade of A, B, or C, corresponding to a reduction in the pass rate by 3.1%. Additionally, the class GPA dropped by 0.18 grade points in the initial offering in hybrid format. However, no attempt was made to determine whether the student composition of the traditional lecture format class consisted of more capable students with greater prerequisite knowledge than the students in the initial hybrid format. Over time, student performance in the hybrid course improved. The reduction in class GPA was only 0.04 for 626 students in 13 hybrid format sections with an average class size of 48. On the other hand, the pass rate remained relatively unchanged at 67.3%.

Concurrently with the switch to hybrid instruction in Mechanics of Materials, the university instituted plus-minus differentiations to letter grades starting in the fall of 2009, and class sizes began to increase. Either of these changes possibly could have impacted the measure of overall student performance or the pass rate and thus required further examination. Under the plus-minus grading scale, a letter grade of A corresponds to a grade point of 4, A- is 3.7, B+ is 3.3, B is 3, and so on until the letter grade of F. A study by Myose *et al.* 2019c[10] on the effect of plus-minus grades on graduation with honors found that slightly fewer Engineering students graduated summa cum laude and magna cum laude without a corresponding increase in cum laudes, which indicated that a plus-minus grading scale appeared to negatively affect some high performing students. In order to see if there were corresponding differences in GPA for marginal students under plus-minus grading, the average GPAs in a variety of different sophomore and junior year courses taught by the first author were compared.[10] Approximately 1000 students graded under the plus-minus system in the first author's classes were compared to the same number of students under whole-letter grade system. Although the number of sophomores and juniors were the same between the two groups, no attempt was made to distinguish between different course topics or the semester in which the course was taught. Results indicated that the GPA under plus-minus grading was lower by about 0.2 grade points. However, average class sizes also increased during the same period from 40 to 54. It is reasonable to speculate that the difference in class size may have affected the GPA, perhaps more than the effect of changing to plus-minus grades. However, the results were inconclusive because the two factors could not be studied independently.

There was additional concern that the hybrid format negatively affected student retention. As a result, faculty teaching Engineering Mechanics began an endeavor to try to understand the issues associated with student retention. The first step in this effort involved quantifying incoming student capability with tests on prerequisite material in Statics and Mechanics of Materials courses. Results showed that the pre-tests were moderately correlated with the end of semester grade point with Pearson correlation coefficient of ~0.45 for Statics and ~0.5 for Mechanics of Materials. Therefore, the pre-test provides a useful measure of incoming student prerequisite knowledge and capability.

In order to understand the cause of the decrease in the pass rate, the first author conducted a series of informal surveys in his hybrid Mechanics of Materials sections to determine if the change might have resulted from the shift to hybrid instruction. The first survey indicated that only half of the students watched most of the videos, while a fourth watched less than half of the videos. Furthermore, only a third of the students responded that they took detailed notes constantly while watching the videos. Most students acknowledged that they took some notes, but the regularity at which the notes were taken and the level of detail contained in those notes were not easily quantifiable. In the second informal survey, Engineering Mechanics students from several Statics and Mechanics of Materials sections at Wichita State University were asked about their time commitments. Students received feedback about their answers for time commitments including calculated total hours per week so that they could make changes if their exam performance early in the semester was poor. Students from both groups had similar commitment levels, averaging a total of about 65 hours a week of coursework, employment, extracurricular activities, and other commitments, such as commuting and household chores. Some students had the equivalent of 100+ hours per week of study, work, and other commitments, assuming that the student met the standard expectation of 2⅔ hours of study and class time combined per credit hour of coursework taken. For students who were overcommitted, the amount of study time likely suffered as a result. It is speculated that marginal or heavily time-committed students may allocate less time to regular study, particularly in a hybrid format class, where they might assume that they can catch up by "binge" watching the videos just before the exam. Such students likely found that the amount of material to watch immediately before an exam was insurmountable.

## Effect of Attendance in Face-to-Face Portion of a Hybrid Course

Based on the responses to the surveys described in the previous section, there was a question about whether the hybrid format made it easier for students to disengage from the course, resulting in a negative effect on student performance. To encourage students to remain engaged with the material, the idea of increasing student attendance in the face-to-face portion of the hybrid course was proposed. Prior to implementing this strategy, the effect of attendance on student performance in the current hybrid format needed to be evaluated. The first and second authors tracked attendance in the face-to-face meetings of their hybrid Mechanics of Materials classes consisting of 454 students in 10 sections that used the same out-of-class videos and problem sets. Attendance in the face-to-face class meetings was voluntary and was tracked without counting it as an official part of the semester grade. The results are shown in Figure 3 and Table 3.

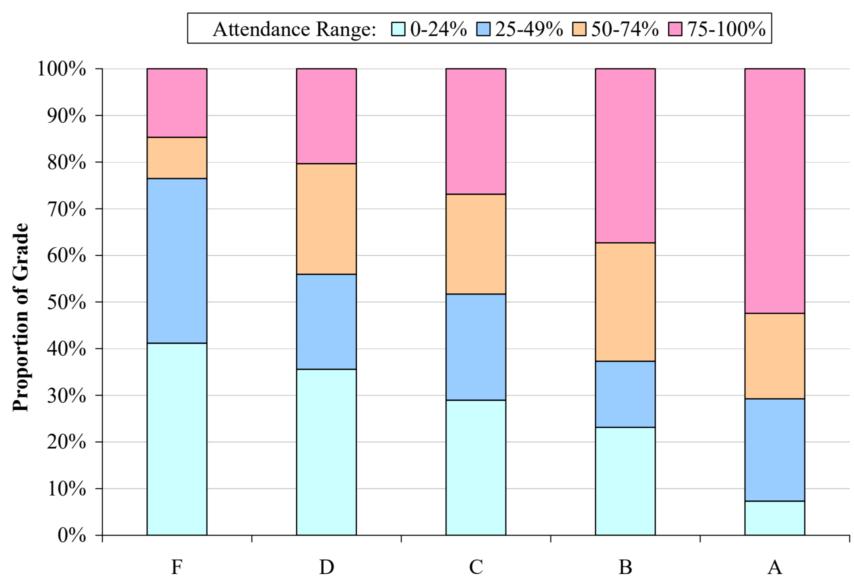


Figure 3. Proportion of each grade as a function of attendance.

Figure 3 shows that more than half of the students who earned a grade of A or A- attended 75-100% of the face-to-face meetings, and about 70% of A or A- students attended the majority of the face-to-face meetings. On the other end of the spectrum, 75% of the students who failed the course attended less than half of the face-to-face meetings. Table 3 shows the difference between the GPA of students who attended a given percentage of face-to-face meetings compared to the average GPA for the course. Students who attended a majority of the face-to-face meetings had a GPA that was +0.42 grade points greater than the average GPA for the course, while students who rarely attended had a GPA that was -0.38 grade points less. This result indicates that there is almost a whole letter grade difference between these two groups. The general trend of increased performance of students who attend more face to face meetings is consistent with results at other universities for both hybrid[11] and traditional lecture[12] style classes.

Table 3. GPA Difference for Each Attendance Category

| Range of face-to-face attendance | 0-24% | 25-49% | 50-74% | 75-100% |
|---|---|---|---|---|
| Number of students in attendance range | 114 | 94 | 97 | 149 |
| GPA for group minus average course GPA | − 0.38 | − 0.13 | + 0.08 | + 0.42 |

While the attendance results do not definitively prove that class attendance improves student performance, they may be an indicator of student engagement with the material outside of the formal classroom. Students who are engaged and motivated are more likely to attend the face-to-face meetings. Nevertheless, the results suggested that student performance might be improved if attendance was increased. Attendance in the face-to-face portion of the hybrid course was required by the first author starting in Spring 2017. The weighting of the semester grade was changed so that attendance counted as approximately 2-3% of the final grade. Additionally, students were told that they would receive a one letter grade deduction if they did not attend 90% of the face-to-face meetings after accounting for excused absences. Due to this policy, non-compliance was very rare, and the deduction was required only for about one out of 100 students. The results of the mandatory attendance policy are shown in Table 4. Once mandatory attendance was instituted, the percentage of the class with a grade of D, F, or W dropped by 10% relative to traditional face-to-face instruction, and the class GPA increased to +0.14 grade points above the reference GPA. In comparison to the optional-attendance hybrid format class, mandatory attendance resulted in a 12.5% improvement in the pass rate and a +0.18 grade point increase in the class GPA.

Table 4. Pass Rate and Average Class GPA Difference for Different Class Formats

| Class format | Ave class size | Pass rate | GPA vs. reference |
|---|---|---|---|
| Face-to-face (reference) | 22 | 69.8% | 0 |
| Hybrid format: attendance optional, full letter grade | 47 | 66.7% | − 0.18 |
| Hybrid format (long term): attendance optional, 2 sect @ full letter grade & 11 sect @ +/- grading | 48 | 67.3% | − 0.04 |
| Hybrid format, attendance required | 41 | 79.8% | + 0.14 |

It should be noted that a preliminary analysis of a similar mandatory attendance requirement in Statics did not appear to affect student performance by a significant amount. However, the majors of students that take Statics and Mechanics of Materials are quite different. Mechanics of Materials is a foundation course taken by sophomores in Aerospace and Mechanical Engineering (AE & ME) who must pass the course with a grade of C or higher in order to take the next course in their major. By comparison, Statics classes are comprised of a varied mix of AE & ME sophomores taking it as a C-or-better required foundation course and seniors from non-AE & ME majors who only need to pass the course with a D- or better. It is likely that non-AE & ME majors do not understand the importance of Statics and may not be as motivated as AE & ME students to do well in the course.

## Summary

A hybrid Mechanics of Materials course consisting of recorded lecture videos and face-to-face class meetings was developed. Initial offerings of the hybrid course resulted in a drop in average student performance by – 0.18 grade points as well as a reduction in the student pass rate of 3%. Over time, average student performance in the course improved; however, the student pass rate remained relatively constant. A number of ad hoc internal studies by the hybrid course instructors were conducted to attempt to determine the factors contributing to the reduction in the student pass rate. Besides the change to hybrid format, some of the factors that may have affected student performance and pass rate include a change in the university's grading system to include plus-minus grades, increased class size, variations in incoming student capability, and the amount of face-to-face class meeting attendance. Unfortunately, these factors could not easily be considered separately and independently. Internal studies suggested that a lack of student engagement as manifested by poor attendance in face-to-face class attendance contributed to poor performance and reduced student retention. The hybrid course policy was changed to include attendance in the end-of-semester grade and incorporated a one letter grade penalty for students who did not have good attendance. This resulted in an improvement in average performance by 0.18 grade points and an increase in the pass rate of 12.5% compared to the optional-attendance hybrid course.

## Bibliography

1. N. Augustine, "America's Education Problem Isn't Money, It's How We Spend It," 8 Jun. 2012, *U.S. News and World Report*.
2. Bureau of Labor Statistics, "Employment in STEM occupations," retrieved on 12 Aug. 2020 from https://www.bls.gov/emp/tables/stem-employment.htm.
3. X. Chen and M. Soldner, "STEM Attrition: College Students' Paths Into and Out of STEM Fields," Nov. 2013, *National Center for Educational Statistics, U.S. Department of Education*.
4. R. Myose, S. Raza, K. Hoffmann, and A. Ghoddoussi, "Correlating Engineering Statics Student Performance with Scores of a Test over Prerequisite Material Involving Problem Solving," Sep. 2014, *Proceedings of the 2014 Midwest Section Conference of the American Society for Engineering Education*.
5. J. Thomas, R. Hall, T. Philpot, and D. Carroll, "The Effect of On-line videos on Learner Outcomes in a Mechanics of Materials Course," 2011, *Proceedings of the American Society for Engineering Education Annual Conference*.
6. R. Myose and E. Rollins, "A Hybrid Mechanics of Materials Course Part 2: Effect of a Sudden Change to Fully Online Format," Oct. 2020, submitted to the *2020 North Midwest Section Conference of the American Society for Engineering Education.*
7. R. Myose, S. Raza, E. Rollins, B. Buerge, and N. Smith, "Prerequisite Testing as a Tool to Gauge Incoming Student Capability and Knowledge in an Engineering Statics Course," Sep. 2019a, *Proceedings of the 2019 Midwest Section Conference of the American Society for Engineering Education*.
8. N. Smith, R. Myose, S. Raza, and E. Rollins, "Correlating Mechanics of Materials Student Performance with Scores of a Test over Prerequisite Material," Oct. 2020, submitted to the *2020 North Midwest Section Conference of the American Society for Engineering Education.*
9. R. Myose, L.S. Miller, E. Rollins, "Student Performance Characteristics in a Hybrid Engineering Statics Course," Sep. 2019b, *Proceedings of the 2019 Midwest Section Conference of the American Society for Engineering Education*.
10. R. Myose, E. Rollins, K. Hoffmann, K. Engber, and S. Myose, "The Effect of Plus-Minus

Grades on Graduation With Academic Distinction for Engineering Students at Wichita State University," Sep. 2019c, *Proceedings of the 2019 Midwest Section Conference of the American Society for Engineering Education*.

11. M. Elmore and K. Gieskes, "Attendance in Large Engineering Classes and Its Effect on Student Performance," 2013, *Proceedings of the American Society for Engineering Education Annual Conference*.
12. J. Durfee, W. Loendorf, D. Richter, T. Geyer, and D. Munson, "A Formal Research Study on Correlating Student Attendance to Student Success," 2012, *Proceedings of the American Society for Engineering Education Annual Conference*.

## Biographical Information

ROY MYOSE is a Professor of Aerospace Engineering at Wichita State University.

FOO NGAI KOK is a Lecturer of Aeronautics & Astronautics at the University of Southampton Malaysia.

ELIZABETH ROLLINS is an Associate Teaching Professor of Aerospace Engineering at Wichita State University.