Student Performance Characteristics in a Hybrid Engineering Statics Course

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Presentation Outline

- Background and motivation

- Describe the advantages of hybrid-style course

- Define topical coverage and exam structure

- Discuss student performance for exams during the semester

- Obtain a benchmark for performance based on cumulative averages

Background

- Significant growth & demand for STEM graduates in U.S.
  - o Studies have shown that 50-85% of U.S. GDP growth is due to advances in science & engineering*
- One roadblock to increasing Engineering graduation numbers is the issue of student retention
- A common bottleneck in Engineering is Statics
  - o 56% pass rate at Cal Poly Pomona
  - o 61% pass rate at Univ of Texas – Pan American
  - o 65% pass rate at Wichita State for 1760 students
  - o Comparable 66% pass rate for 1st author's hybrid classes

*Norm Augustine, *U.S. News & World Report*, 8 June 2012

Motivation for Benchmark Data

- Hybrid class by the first author has a comparable pass rate

- To increase retention and improve student success, interventions will be necessary

  o However, the efficacy of interventions cannot be objectively assessed without a benchmark

- Goal is to obtain a benchmark for student performance over the course of the semester for a hybrid Statics class

Advantages of Hybrid Course

- A hybrid course includes videos of concept development and example problems viewed outside of class
  - The videos allow students to go over difficult concepts multiple times by pausing and rewinding the videos
  - Dovetails with current students who desire study material any time, anywhere
- Opens up class time to solve additional examples and spend time on review prior to exams
- Class periods become available to increase the number of exams, each of which become a smaller fraction of the final grade
  - Section coverage in each exam becomes limited rather than wide-ranging, so exams are more like quizzes in terms of coverage
  - Students may be able to recover from one poor exam score compared to classes with only a few exams

Organization and Topical Coverage

Different for 50 min class vs 60 & 75 min classes

Week	Exam	50min Class [# Lessons]	60&75min Class [# Lessons]	Exam	Week
3	1	Ch2 Force Vectors [4]	Ch2 Force Vectors [5]	1	4
5	2	Ch2 *continued* [1] & Ch3 Force Equilibrium [2]	Ch3 Force Equilibrium [2] & Ch 4 Moments [2]	2	6
7	3	Ch 4 Moments [4]	Ch4 *continued* [3] & Ch5 Rigid Body Equilibrium [2]	3	7
9	4	Ch4 *continued* [1], Ch5 Rigid Body Equilibrium [3], & Ch6 Trusses [1]	Ch5 *continued* [1] & Ch6 Trusses & **Frames** [3]	4	10
10		Last Day for Withdrawal	Last Day for Withdrawal		10
11	5	Ch6 Trusses & **Frames** [2] & Ch7 Internal Forces [2]	Most difficult: Frames	5	12
13	6	Ch7 Internal Forces *cont.* [1] & Ch8 Friction [2]	Ch9 & 10 Section Prop [5]	6	15
15	7	Ch9 & 10 Section Prop [5]			

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Dataset for the Benchmark

- Dataset consists of 343 students in the first author's hybrid classes
  - o 152 students in four 50-minute sections with 7 regular exams
  - o 117 students in three 75-minute sections and 74 students in two 60-minute sections (i.e., 191 total students) with 6 regular exams
  - o In addition to regular exams, all students took a prerequisite knowledge test at the start of the semester and a comprehensive final exam

- ~11% of the students withdrew from the course with a grade of W
  - o Some students remained in the class even though they were flunking at 10th week, often to maintain financial aid or immigration status
  - o Those who did not take the exams were not a part of the cumulative averages – change in class composition can affect statistical results
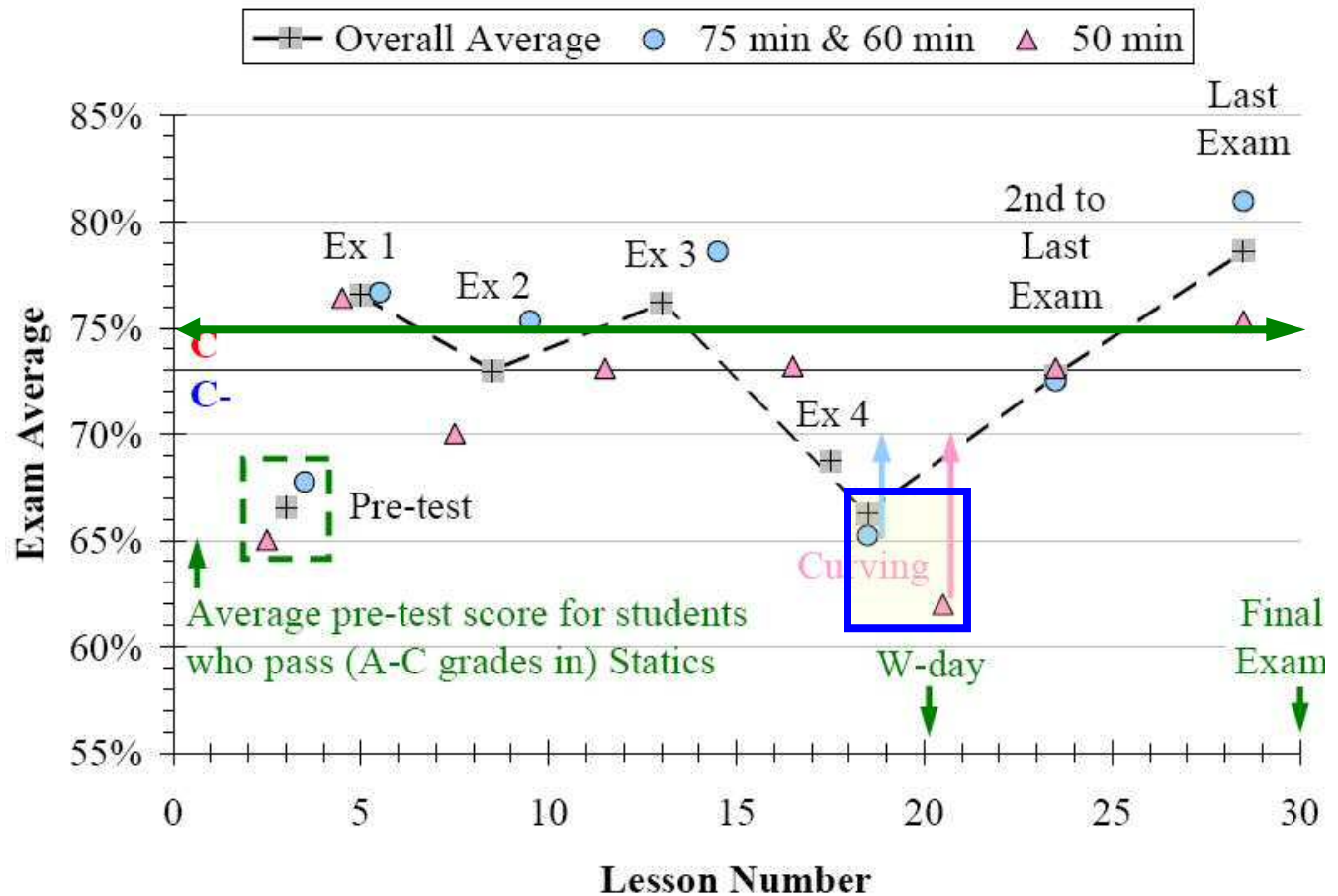
Individual Exam Averages
Over the Course of a Semester

- Performance by 50-min class was **lower** than 60- & 75-min classes

- Reason: they were less capable as indicated by lower prerequisite test score (topic of earlier paper)

- Exam 1 is review so many do very well, but this is not evident from the average
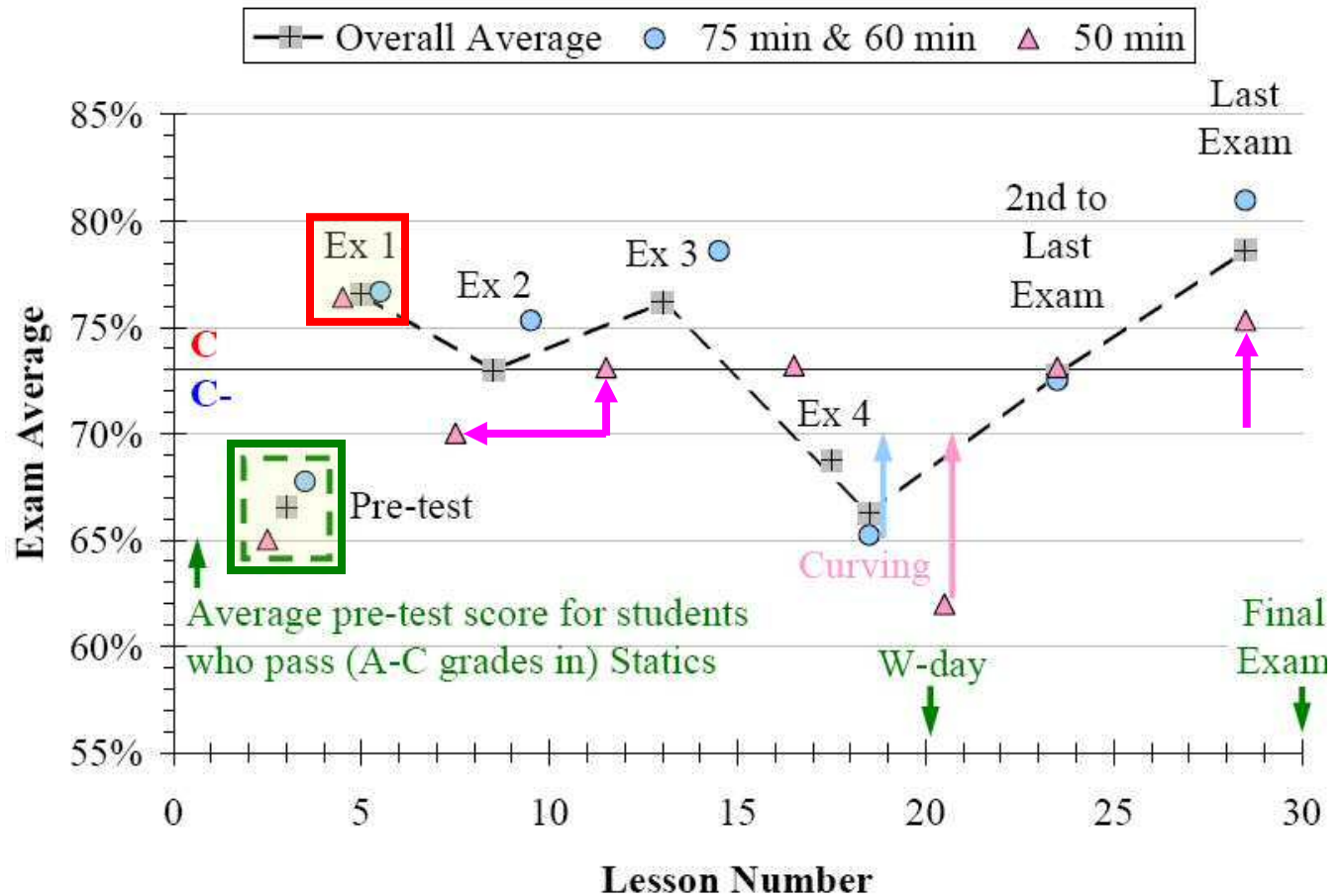
Individual Exam Averages
Over the Course of a Semester

- Result on exam over frames is poor because it is the most difficult material in course
- Except for frames, exam performance appears relatively constant (to ±5%)
- Poor students dropping over time masks difference in performance
- Need to look at cumulative ave

Legend: Overall Average | 75 min & 60 min | 50 min

Y-axis: Exam Average (85%, 80%, 75%, 70%, 65%, 60%, 55%)

C
C-

Ex 1
Ex 2
Ex 3
Ex 4
Pre-test
Curving
2nd to Last Exam
Last Exam

Average pre-test score for students who pass (A-C grades in) Statics

W-day
Final Exam

X-axis: Lesson Number (0, 5, 10, 15, 20, 25, 30)

Cumulative Statistics (Average & Standard Deviation) During Semester

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

- Divided into groups: those that pass, all (reference), and not passing
- Cumulative average do not vary significantly within each group

Cumulative Performance Over the Course of the Semester

Analysis based on averages alone obscures trends

Distribution of averages over semester
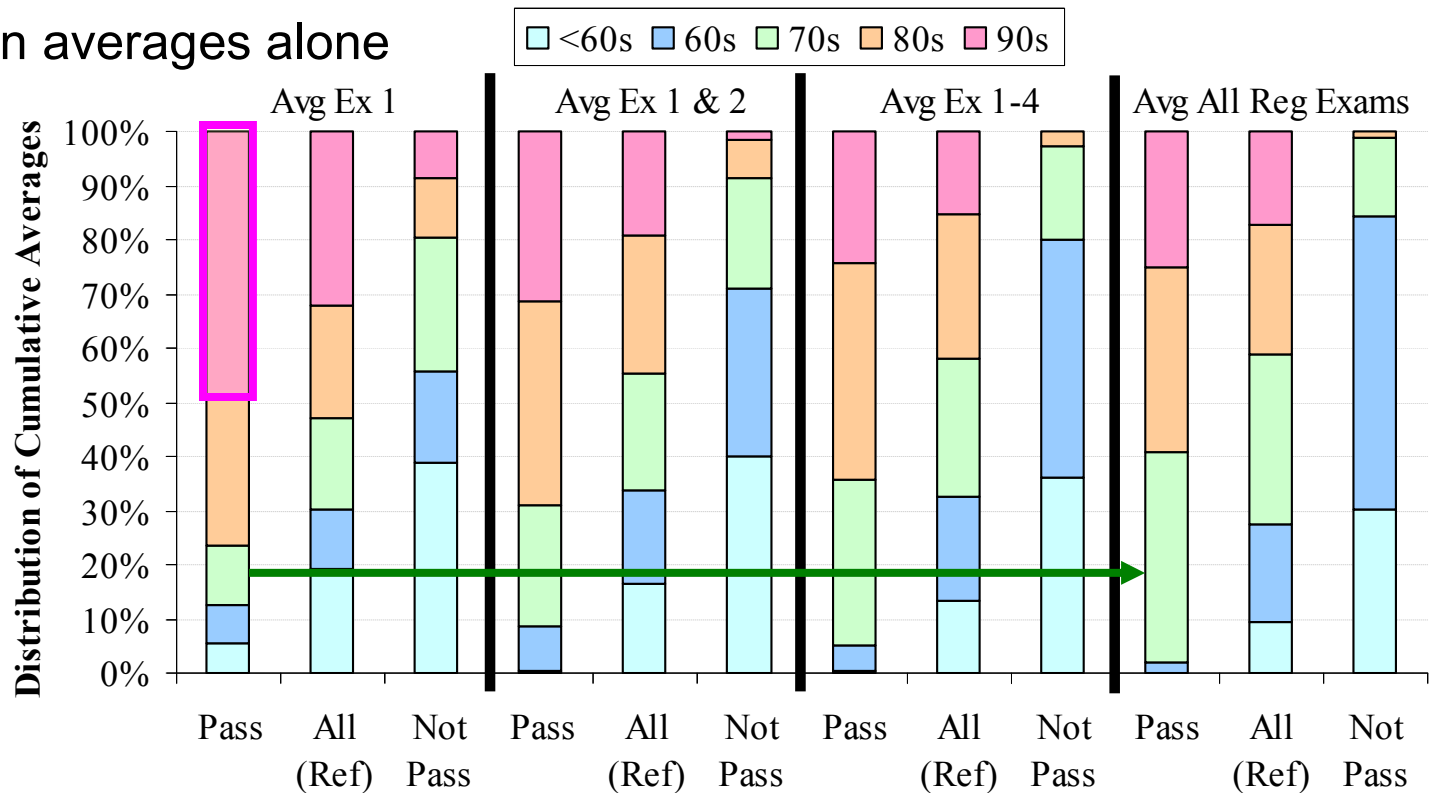
- Exam 1 is review, so half of those who pass earn 90's
- Over the semester, number of A's decrease while number of C's increase

Correlation Between Exam Scores and Semester Grade

- Pearson correlation coefficient between exam scores and semester grade were determined

- Pearson correlation coefficient ranges between +1 and -1

  o It is +1 when it is perfectly correlated

  o 0 when there is no correlation at all

  o -1 when an increase in one variable leads to a decrease in the other

  o Results are less scattered when the correlation coefficient approaches +/-1

Correlation Between Exam Scores and Semester Grade

- Correlation coefficient between **individual** exams & semester grade:

Pre-test	Exam 1
0.457	0.628

Pre-test = moderate correlation   Exam 1 (only) = moderately high

- Correlation coefficient between **cumulative** ave & semester grade:

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

very high $\longrightarrow$ near perfect correlation

- Very high correlation by the fourth exam, when the last day to withdraw with a grade of W occurs

Correlation Details: Pre-test, Exam 1 & 2 Average with Semester Grade

- **Least squares fit lines** shown: Exam 1 (only), cumulative ave of Ex 1 & 2, and Pre-test (only)

- **Data points** for Ex 1 & standard deviation (SD) at each grade pt are also shown

- SD ("error") bars show range of values for each grade pt
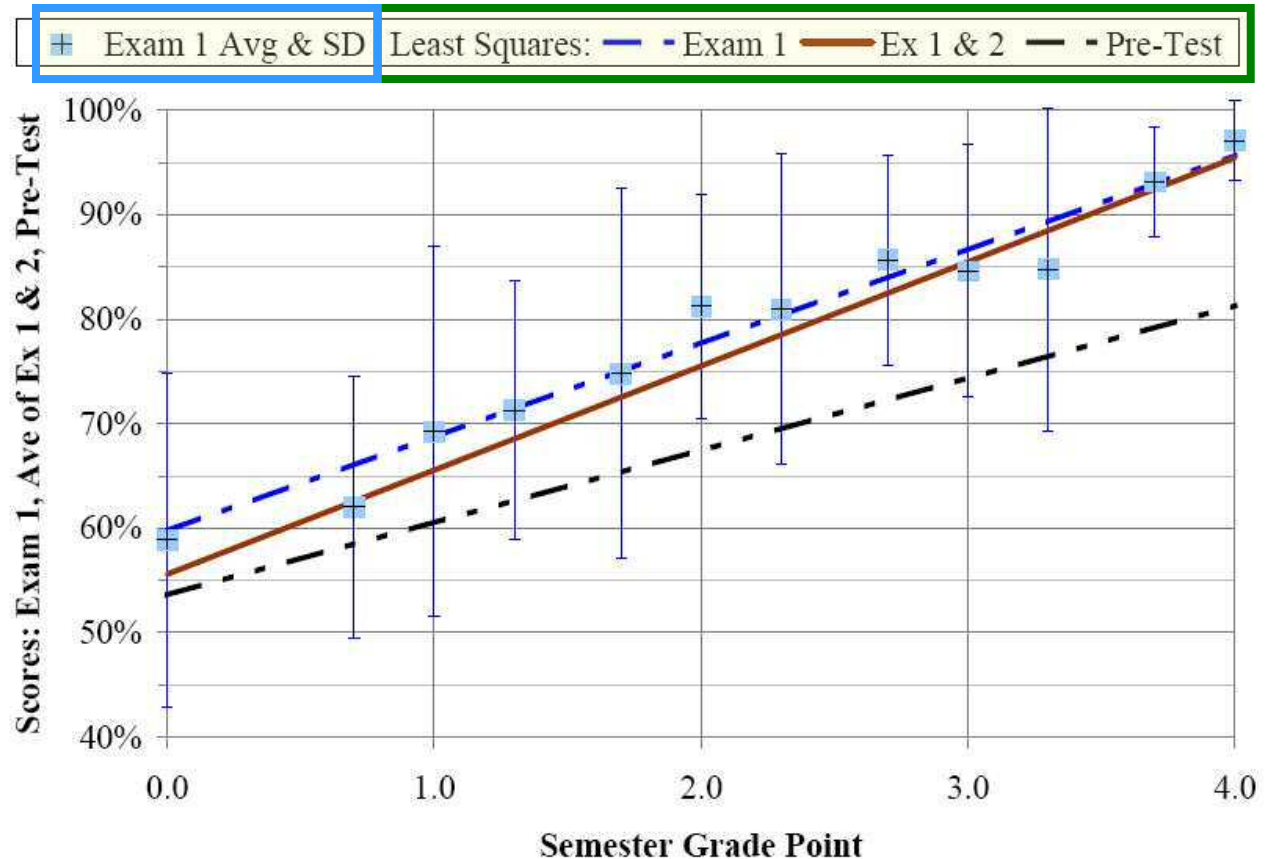
# Correlation Details: Pre-test, Exam 1 & 2 Average with Semester Grade

- For Ex 1, **average score** at each grade pt is often above the typical grade range
- E.g., those with C's for semester grade have 81% average on Ex 1

- There is also a very high variance
- E.g., those with C+ have **SD of ±15%** even though grades are only ±1.5% wide
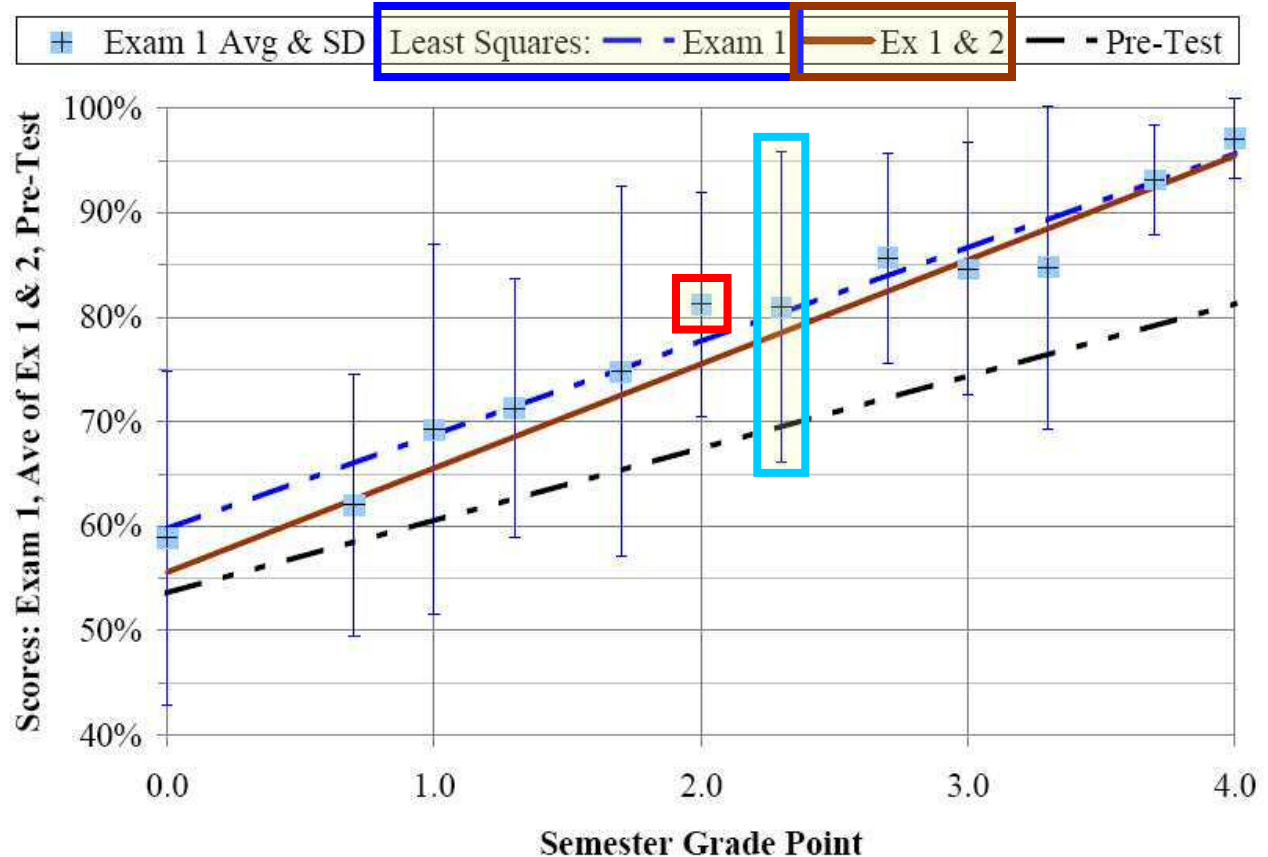
- Cumulative ave of **Ex 1 & 2** lowers typical score

Correlation Details: Exam 1-4 Cumulative Average & Grade

- **Data points** for cumulative ave & SD of Ex 1-4 at each grade pt are shown

- By Ex 4, cumulative ave least squares fit line has moved close to middle of score range of each grade

- Variance in scores for each grade has also been reduced, though **SD** is still more than $\pm$1.5%

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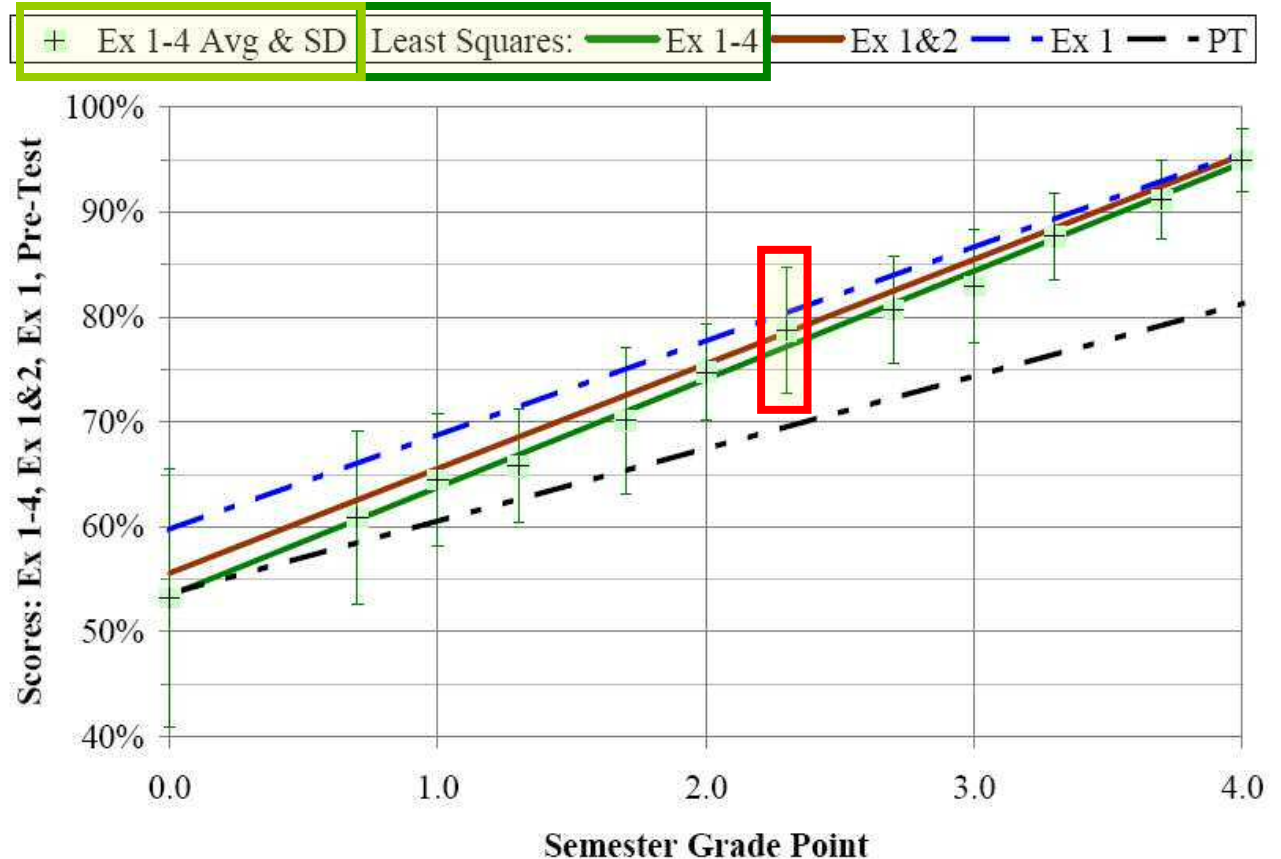
Correlation Details: All Regular Exam Cumulative Average and Grade

After all regular exams (except for final exam):

- Not much shift in cumulative ave line except at lower grade levels

- Variance in scores has reduced to about ±2% to 3%

- Results are close to grade level values & range as expected since correlation coefficient is **0.947**
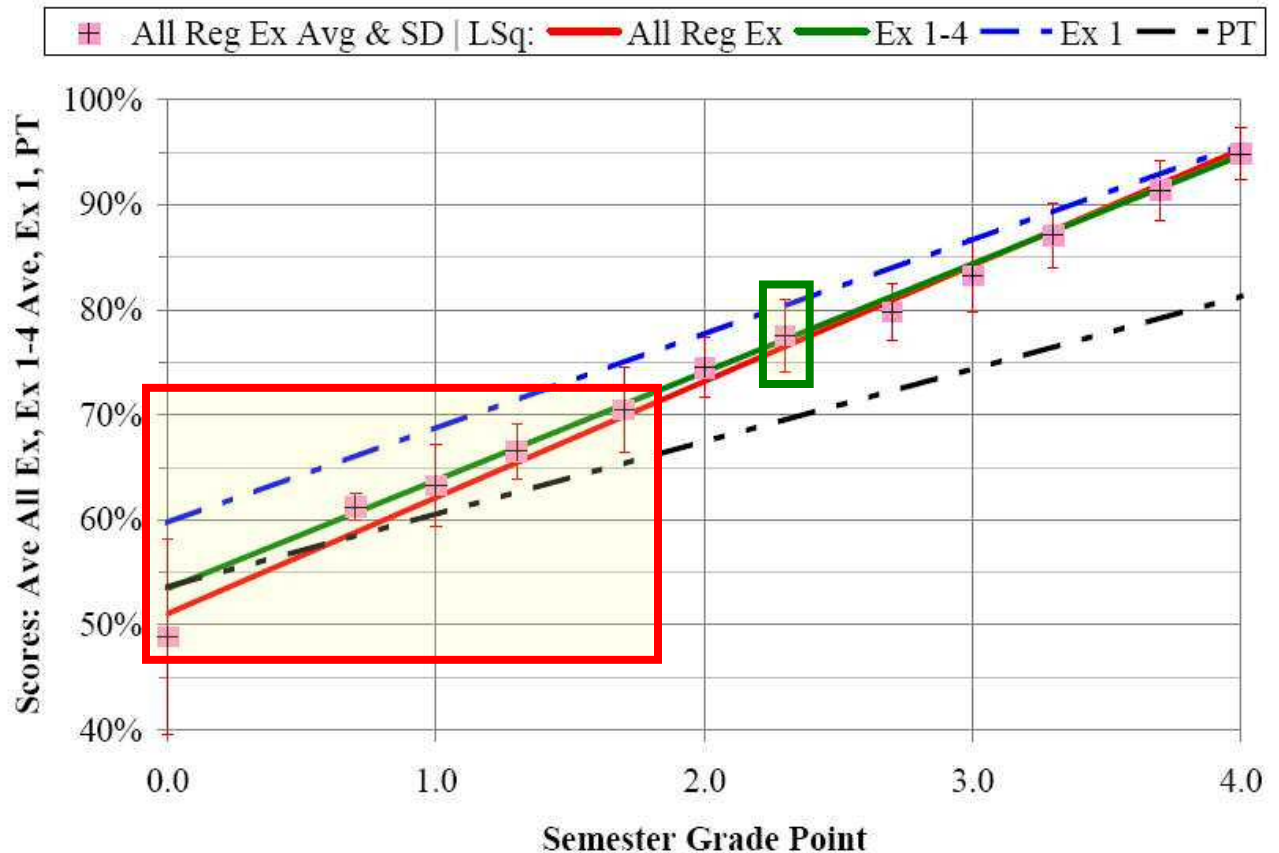
- There is still some room to improve with the final, but it is limited

Summary

- Student performance characteristics in a hybrid Statics class were investigated

- Cumulative averages did not vary much over the semester, but the distribution of scores varied a lot

- Decreasing amounts of variance in the 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

- There is a limit to the amount of improvement that is possible just with the final exam; i.e., after the completion of the regular semester exams

- These results provide a benchmark for comparison in the future when interventions are made to affect student success in Statics at WSU