

STAT 2600 Final Project

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Ask a Question

CDE administrators are interested in looking at the academic performance of 9th graders in the time period between 2009 and 2011. During this period the test results for math were particularly low in the State of Colorado. However, increased focus on the math curriculum for beginning high school students is supposed to have improved student performance over that time frame. Administrators hope to better understand the transition in test scores between years and apply any valuable insights to future initiatives.

Specifically, the administrators are seeking answers to the following questions:

1. Was there truly an improvement in passing rates for the math exam between 2009 and 2011? If so, was there a decline in performance on the reading and writing exams?
2. Was there an association between a school's passing rate on the math exam and its passing rates on the reading and writing exams? If so, how accurately could math passing rates have been predicted from the reading and writing rates?

These questions matter because they help administrators evaluate whether statewide performance actually changed over the time period and whether subject results move together across schools in a way that could inform future planning.

Acquire the Data

The dataset contains school-level CSAP results for Colorado 9th graders. For each school, subject, and year, the file gives counts of students in the categories no score, unsatisfactory, partial, proficient, and advanced. Passing rate was defined as the proportion of students who scored proficient or advanced out of the total number of students who were tested.

To prepare the data for analysis, total student counts were computed by summing the score categories, and passing rates which were then calculated for each school, subject, year combination. The data was reshaped so that passing rates from multiple years could be compared within the same school and subject. This made it possible to calculate the changes in passing rates between years and to build prediction models across the given subjects.

A clerical error described in the course announcement affects the math data. The 2011 math scores were copied from the 2010 math scores, this meaning valid math results for 2011 are not available. Because of this, math was only analyzed for the 2009 to 2010 transition, and the predictive models were trained on 2009 data and tested on 2010 data.

Analyze the Data

The original project description called for nine plots, but the course announcement changed the first part of the assignment because the 2011 math data are repeated. As a result, this report includes five change plots and three predictive plots, for a total of eight plots.

Table 1: Estimated mean changes in passing rates with 95% bootstrap confidence intervals.

Subject	Transition	Mean_Change	CI_Lower	CI_Upper
Writing	2009 to 2010	-0.035	-0.049	-0.021
Writing	2010 to 2011	0.036	0.022	0.050
Reading	2009 to 2010	0.001	-0.012	0.015
Reading	2010 to 2011	-0.037	-0.050	-0.023
Math	2009 to 2010	0.046	0.032	0.061

Writing: 2009 to 2010

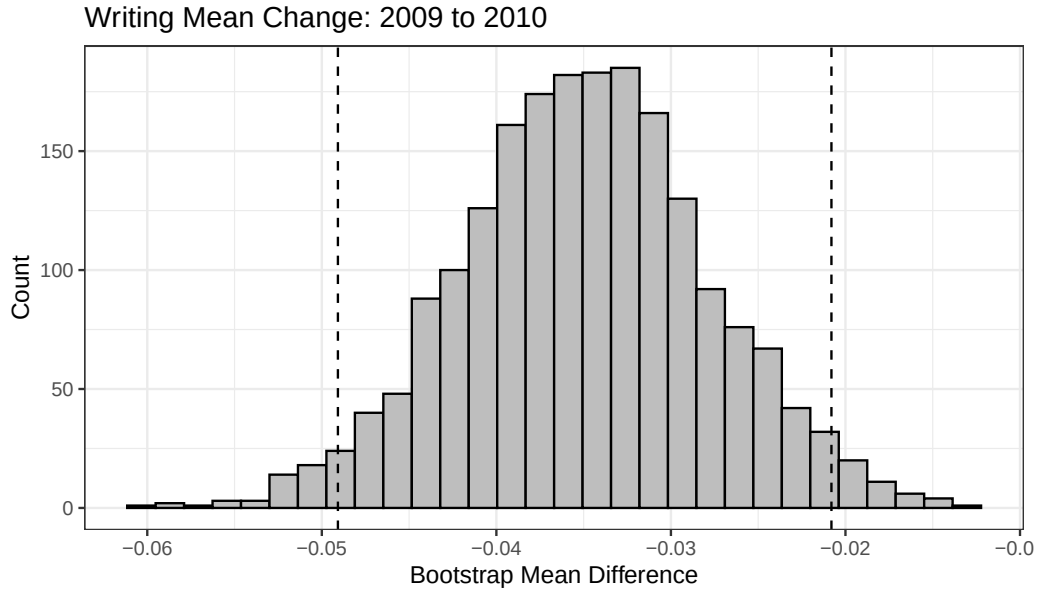


Figure 1: Bootstrap distribution of the mean change in Writing passing rates from 2009 to 2010.

The estimated mean change in writing passing rates from 2009 to 2010 was -0.035. The 95% bootstrap confidence interval was (-0.049, -0.021). Because this interval is entirely below zero, the evidence suggests that average writing passing rates declined across the schools during this period.

Writing: 2010 to 2011

The estimated mean change in writing passing rates from 2010 to 2011 was 0.036. The 95% bootstrap confidence interval was (0.022, 0.05). This interval suggests that writing performance proceeded to rebound after the earlier decline.

Reading: 2009 to 2010

The estimated mean change in reading passing rates from 2009 to 2010 was 0.001. The 95% bootstrap confidence interval was (-0.012, 0.015). Because zero falls inside this interval, the results do not provide strong evidence of a statewide increase or decrease in reading for this time period.

Reading: 2010 to 2011

The estimated mean change in reading passing rates from 2010 to 2011 was -0.037. The 95% bootstrap confidence interval was (-0.05, -0.023). Because this interval is below zero, reading appears to have declined

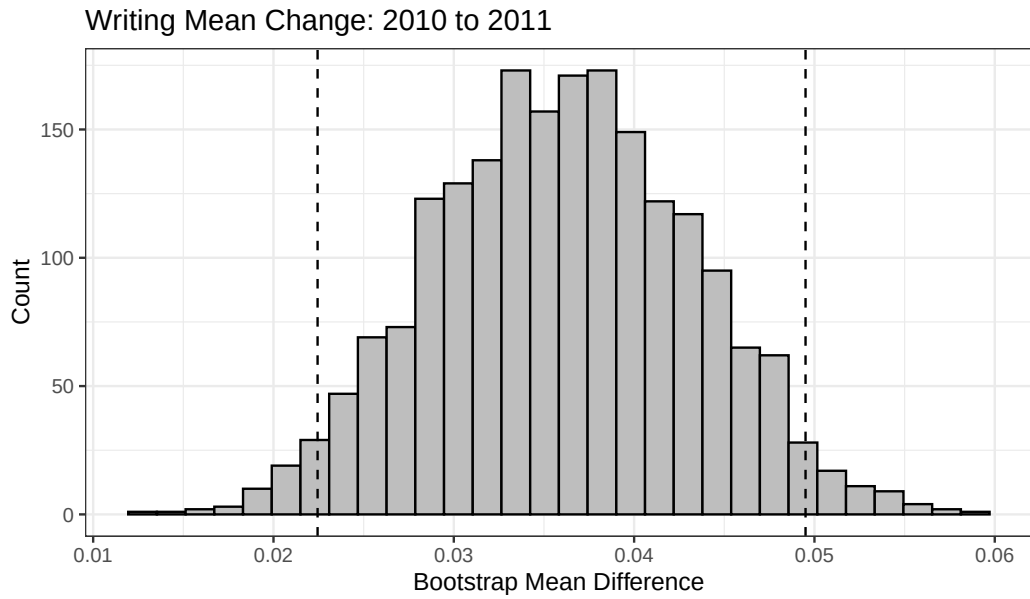


Figure 2: Bootstrap distribution of the mean change in Writing passing rates from 2010 to 2011.

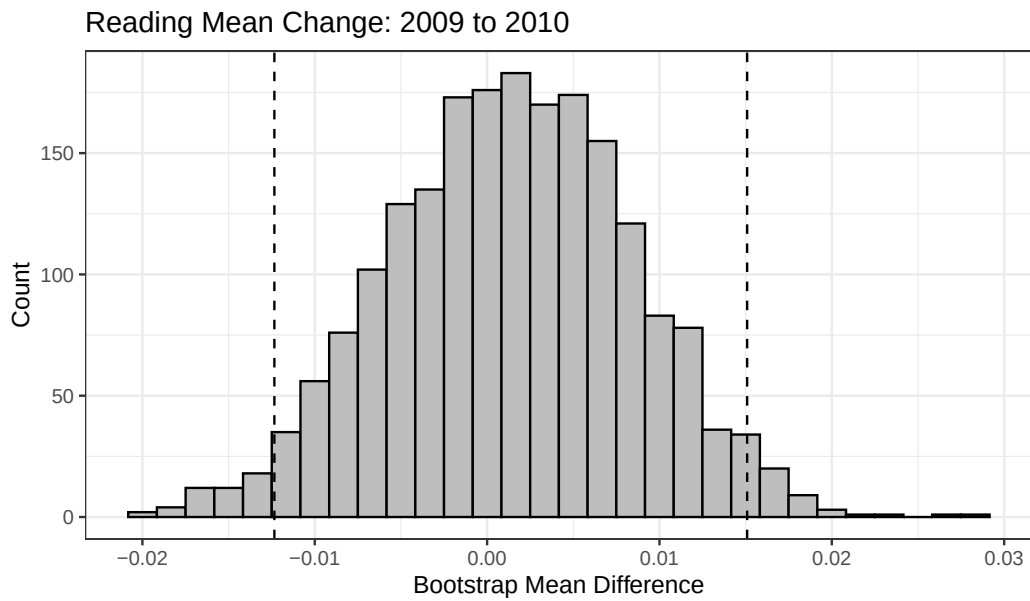


Figure 3: Bootstrap distribution of the mean change in Reading passing rates from 2009 to 2010.

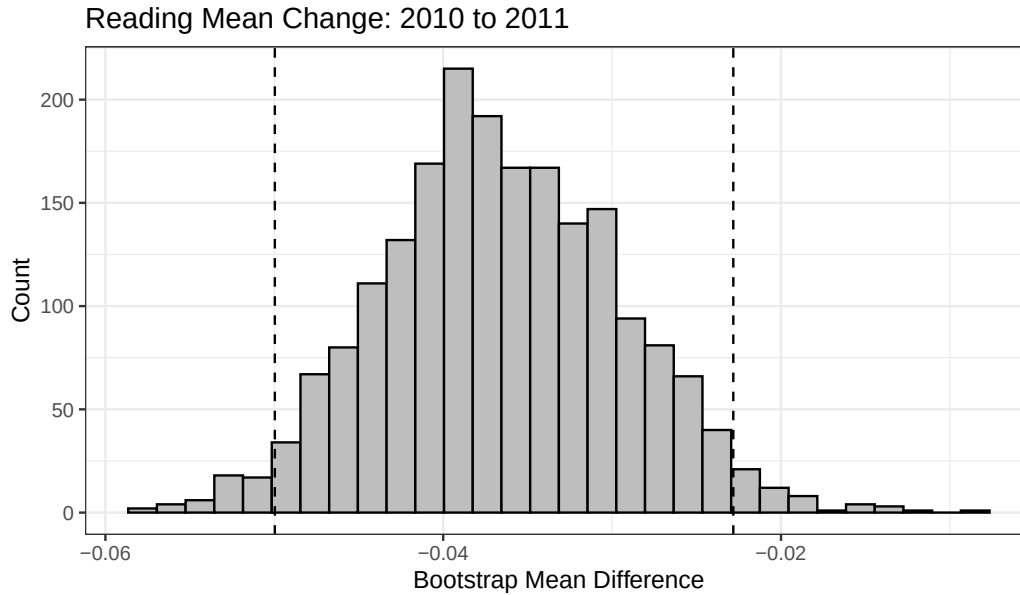


Figure 4: Bootstrap distribution of the mean change in Reading passing rates from 2010 to 2011.

during this time period.

Math: 2009 to 2010

The estimated mean change in math passing rates from 2009 to 2010 was 0.046. The 95% bootstrap confidence interval was (0.032, 0.061). Because this interval is entirely above zero, the evidence supports an increase in math passing rates from 2009 to 2010.

The project announcement states that math scores for 2011 should not be analyzed because the 2011 values are clerical duplicates of 2010. For that reason, no Math 2010 to 2011 change plot is included.

Table 2: Prediction accuracy on 2010 test data measured by RMSE.

Model	RMSE
Reading predicted from Writing	0.064
Math predicted from Reading	0.101
Math predicted from Writing	0.102

Prediction Model 1: Reading from Writing

In the 2009 training data, reading and writing passing rates had a strong positive relationship, with correlation 0.963. The fitted regression equation was $\text{READING} = 0.237 + 0.86 \times \text{WRITING}$. When tested on 2010 data, this model had an RMSE of 0.064.

Prediction Model 2: Math from Reading

Math and reading passing rates were also positively associated in the 2009 training data, with correlation 0.854. The fitted equation was $\text{MATH} = -0.275 + 0.887 \times \text{READING}$. Tested on 2010 data, this model had an RMSE of 0.101.

Prediction Model 3: Math from Writing

Math and writing passing rates had a positive relationship as well, with correlation 0.897. The fitted regression equation was $\text{MATH} = -0.099 + 0.832 \times \text{WRITING}$. On the 2010 test set, this model had an RMSE of 0.102.

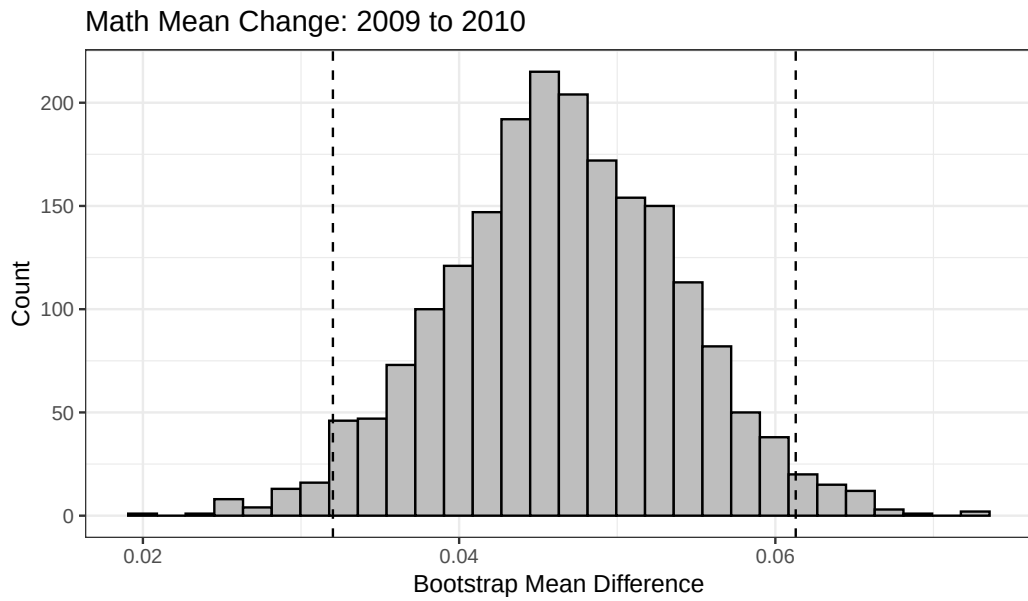


Figure 5: Bootstrap distribution of the mean change in Math passing rates from 2009 to 2010.

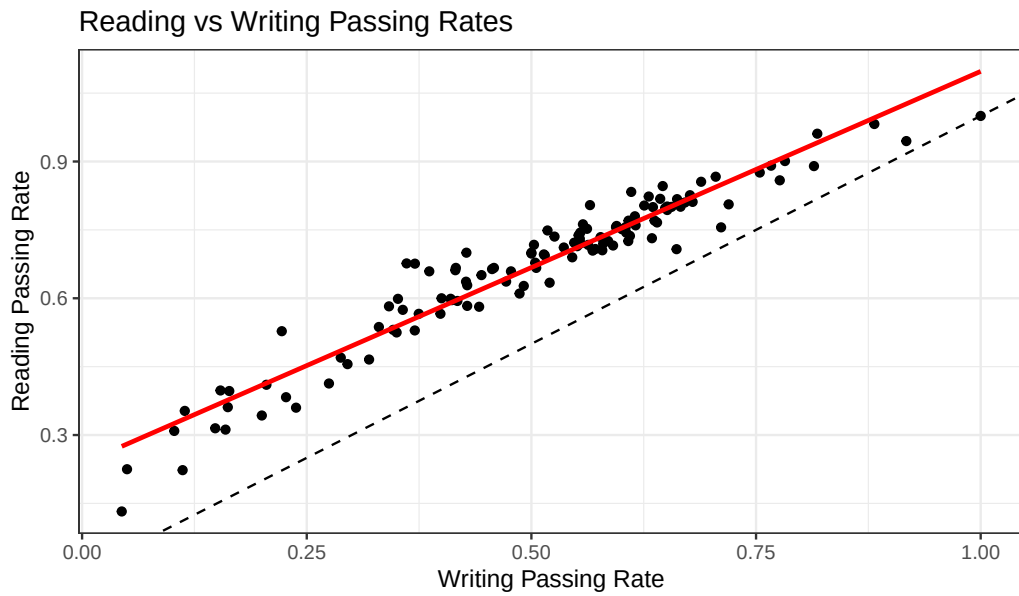


Figure 6: Reading versus Writing passing rates in the 2009 training data with fitted regression line.

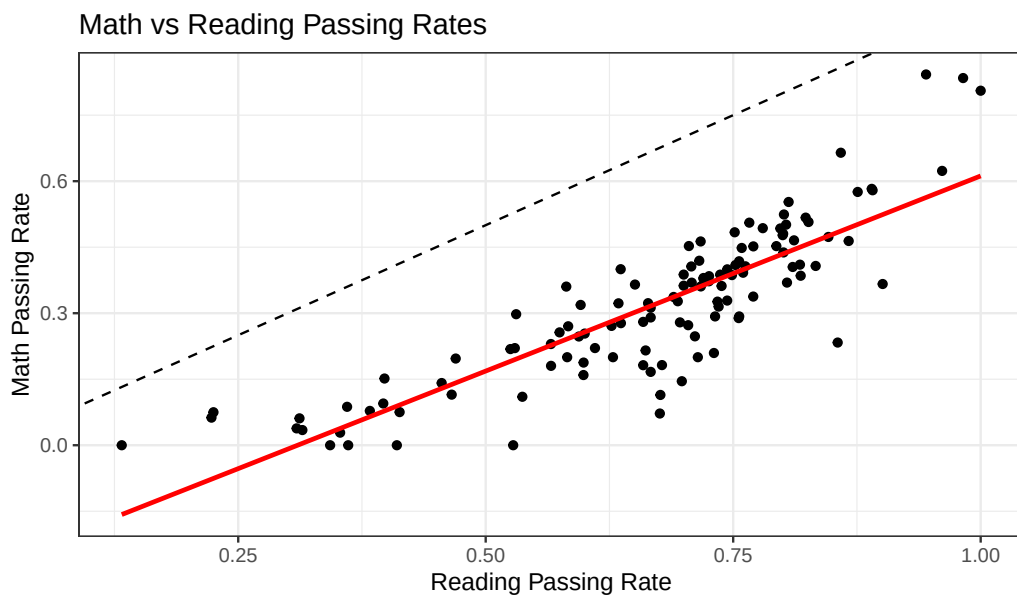


Figure 7: Math versus Reading passing rates in the 2009 training data with fitted regression line.

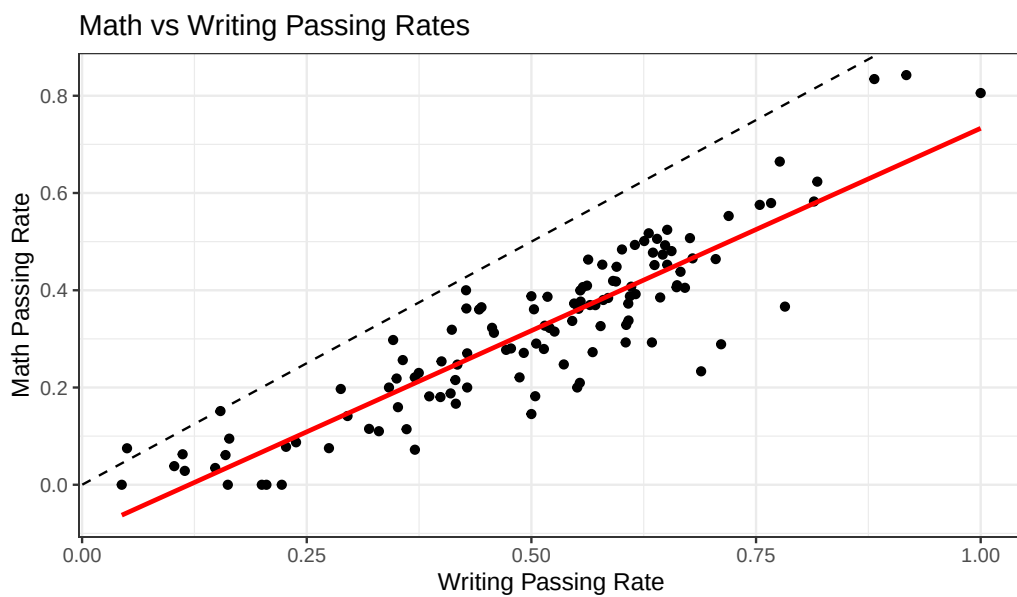


Figure 8: Math versus Writing passing rates in the 2009 training data with fitted regression line.

Advise on Results

The year to year subject results were slightly mixed instead of being uniform. Writing declined from 2009 to 2010 while reading showed little clear change from 2009 to 2010, and math improved from 2009 to 2010. For the 2010 to 2011 time period, reading declined and writing increased. These patterns help suggest that statewide performance did not particularly trend in a single direction across all subjects.

For CDE administrators, the most important practical finding is that math appears to have improved from 2009 to 2010, which is consistent with the stated concern that the math performance had been especially low and may have responded to the increased attention in the classroom. At the same time, reading and writing did not follow the same pattern this which suggests that subject specific supports may be more useful than broad statewide assumptions.

The predictive analysis also helps show that school performance across subjects is related. The schools that had stronger reading and writing passing rates tended to have stronger math passing rates as well. The RMSE values show that these predictions are not totally exact, so prior performance in another subject is helpful and connects the ideas but not enough to make assumptions by itself.

This report also has some limitations. The analysis uses school level collected data rather than student level data, so it cannot explain why individual schools improved or declined. In addition, the clerical error in the math data creates a block from a valid analysis of math from 2010 to 2011.

This report can help inform future initiatives by helping administrators see the benefit of including all subjects to help increase their overall test scores. This can help them form curriculum as well as time spent per subject.

Answer the Question

The first question asked whether there was truly an improvement in passing rates for the math exam between 2009 and 2011 and whether reading and writing declined. Based on the data given, there is evidence that math passing rates improved from 2009 to 2010. Because the 2011 math data was not able to be used, a full 2009 to 2011 math comparison cannot be made. Writing declined from 2009 to 2010, while reading did not show clear evidence of change from 2009 to 2010 but did decline from 2010 to 2011.

The second question asked whether there was an association between a school's math passing rate and its reading and writing passing rates. Also how accurately math could be predicted from those variables. To answer the question yes, both reading and writing were positively associated with math in the training data, and both gave reasonable 2010 test prediction accuracy. This means that subject performance tends to move together across schools, although the prediction error remains large enough that these models should be used as rough summaries rather than exact forecasting tools.

Some recommended future analysis that could be performed is to look further into the math scores and the students performance in those and how it effects other test scores. With the limited data there could be more research done into the benefits or lack of benefits related to higher math test scores.