An Investigation of Grade 3-5 Students' State Test Scores in the Denver, Colorado Area

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I. DESCRIPTION

The purpose of the study is to investigate the relationship between state test score of elementary school students in the Denver, Colorado area and other variables thought to be related. Data were provided as part of the project, which included school ID, student ID, state test score, English portion of the score, math portion of the score, gender, student's grade, and parents' employment for a total of 1402 elementary school students in the Denver, Colorado area (n=1402). A total of 3236 test scores were recorded (obs=3236). State test score is the main response to test, and the rest of the variables are predictors of interest.

State test score ranges from 4 to 36 and has a mean equal to 25.13 and a median equal to 25. English portion of the score ranges from 0 to 98 and has a mean equal to 52.49 and a median equal to 54, and math portion of the score ranges from 1 to 40 and has a mean equal to 26.66 and a median equal to 28. Gender has two levels (1: boy, 2: girl). Grade ranges from 3 to 5 (1154 scores were taken in grade 3; 1129 scores were taken in grade 4; and 953 scores were taken in grade 5). Parents' employment has 9 levels (1: both parents employed, manual laborers; 2: father manual labor, mother non-manual labor; 3: father non-manual labor, mother manual labor; 4: both parents non-manual labor; 5: father employed, mother unemployed; 6: father unemployed, mother employed; 7: both parents long term unemployed; 8: both parents currently employed; 9: father absent).

```
## Loading required package: ggplot2
```

```
## Loading required package: carData
```

```
## 'data.frame':    3236 obs. of  8 variables:
##  $ school.id: Factor w/ 49 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ gender   : Factor w/ 2 levels "boy","girl": 2 2 2 1 1 1 1 1 1 1 ...
##  $ employ   : Factor w/ 9 levels "1","2","3","4",..: 9 9 9 2 2 2 2 2 9 9 ...
##  $ t.score  : int  23 23 23 15 15 22 22 22 14 14 ...
##  $ ID       : Factor w/ 1192 levels "1","2","3","4",..: 1 1 1 2 2 3 3 3 4 4 ...
##  $ english  : int  72 80 39 7 17 88 89 83 12 25 ...
##  $ math     : int  23 24 23 14 11 36 32 39 24 26 ...
##  $ grade    : Factor w/ 3 levels "3","4","5": 1 2 3 1 2 1 2 3 1 2 ...
```

```
##    school.id     gender         employ        t.score            ID
##  48     : 206   boy :1551   4      :1225   Min.   : 4.00   1      :   3
##  33     : 131   girl:1685   9      : 484   1st Qu.:21.00   3      :   3
##  42     : 131               2      : 424   Median :25.00   4      :   3
##  31     : 107               5      : 288   Mean   :25.13   6      :   3
##  47     : 102               3      : 270   3rd Qu.:29.00   7      :   3
##  50     : 101               6      : 221   Max.   :36.00   8      :   3
##  (Other):2458               (Other): 324                   (Other):3218
##     english           math       grade
##  Min.   : 0.00   Min.   : 1.00   3:1154
##  1st Qu.:31.00   1st Qu.:22.00   4:1129
##  Median :54.00   Median :28.00   5: 953
##  Mean   :52.49   Mean   :26.66
##  3rd Qu.:75.00   3rd Qu.:33.00
```

```
##  Max.   :98.00   Max.   :40.00
##
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
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```
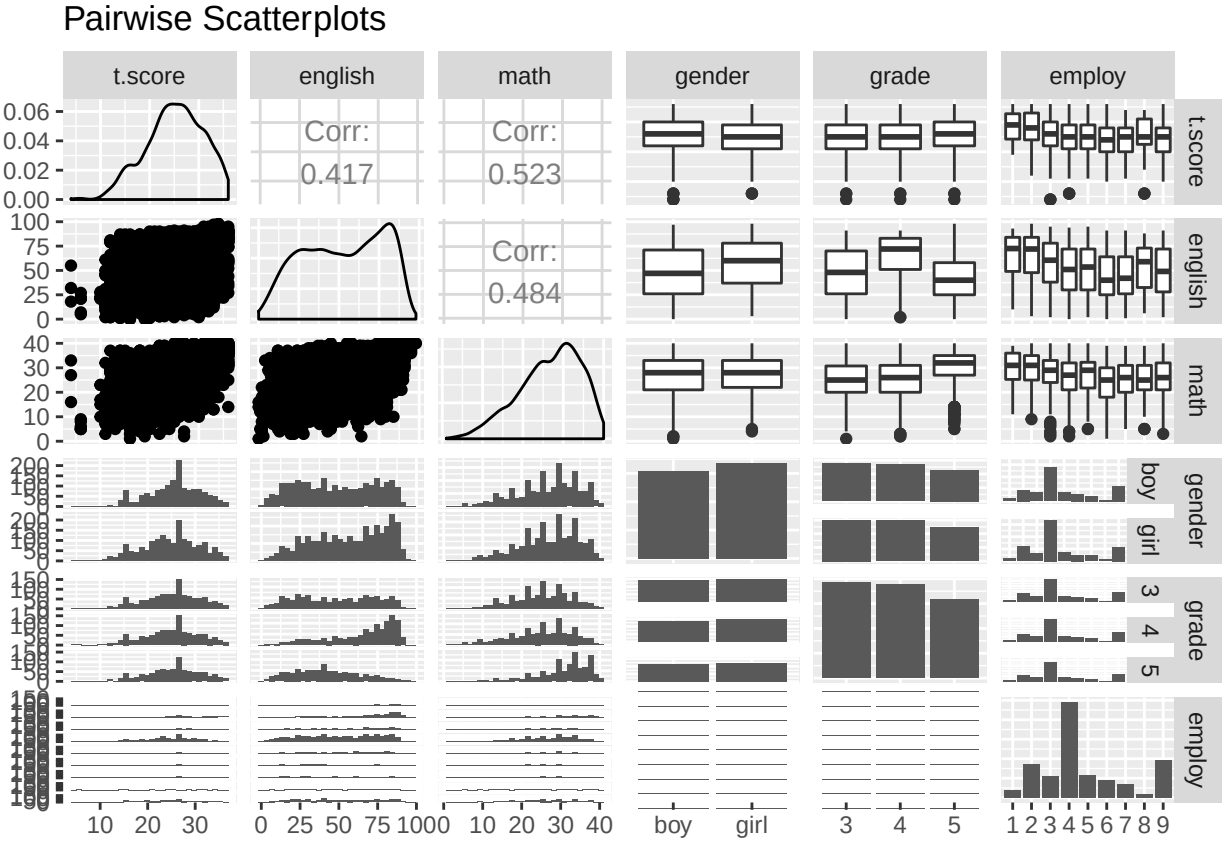
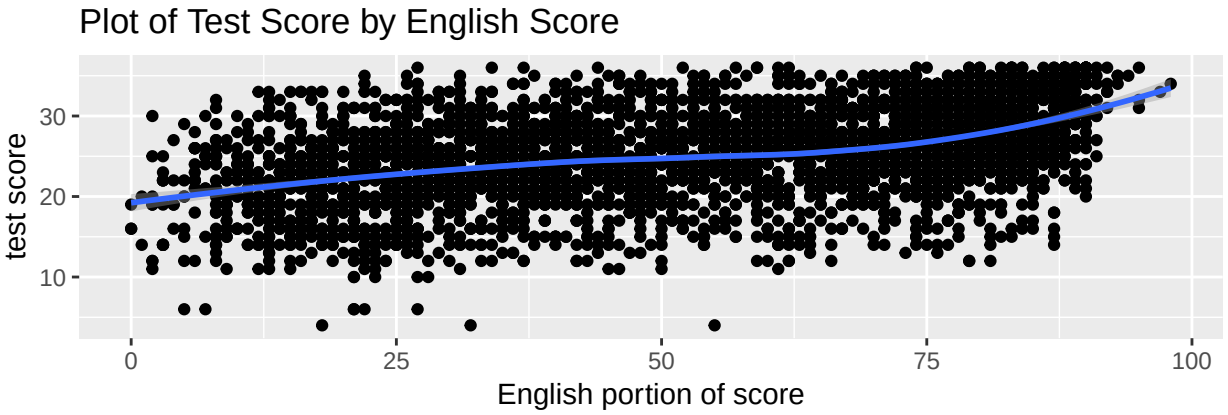
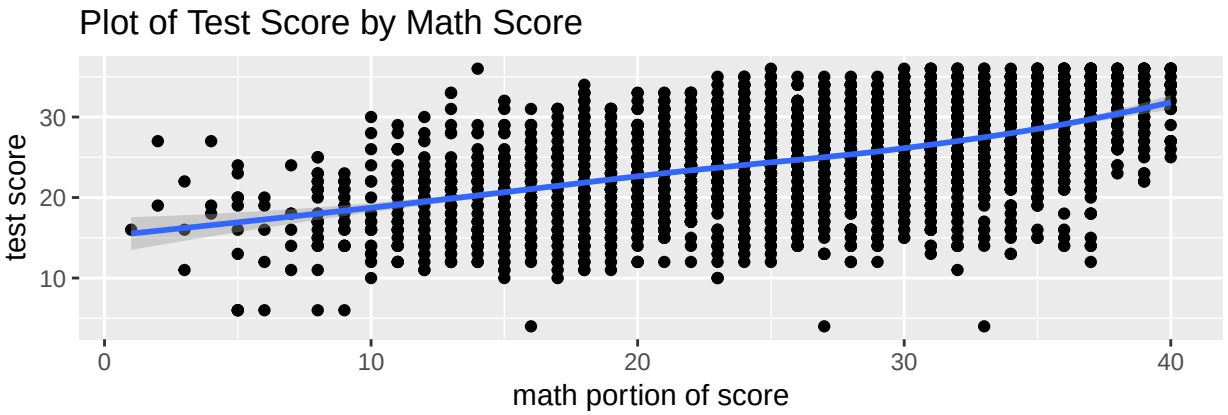



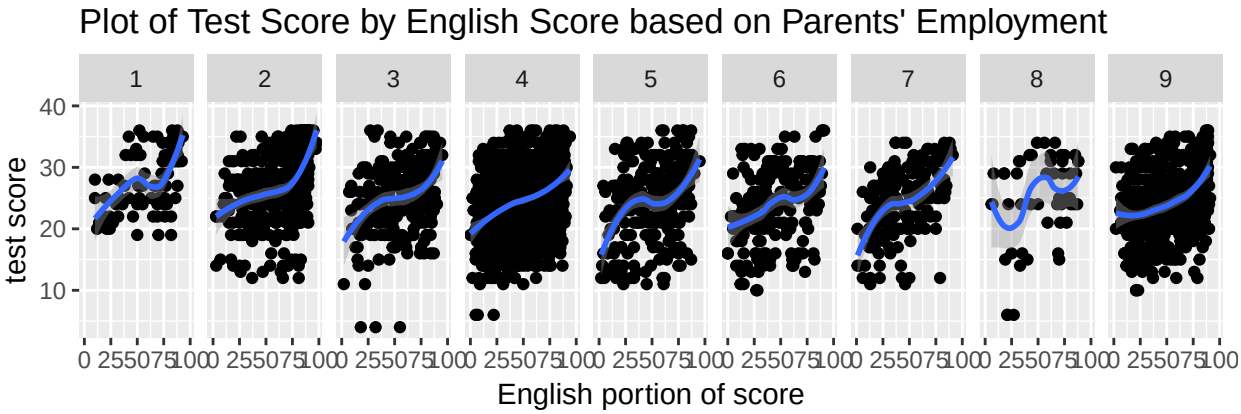
II. ANALYSIS

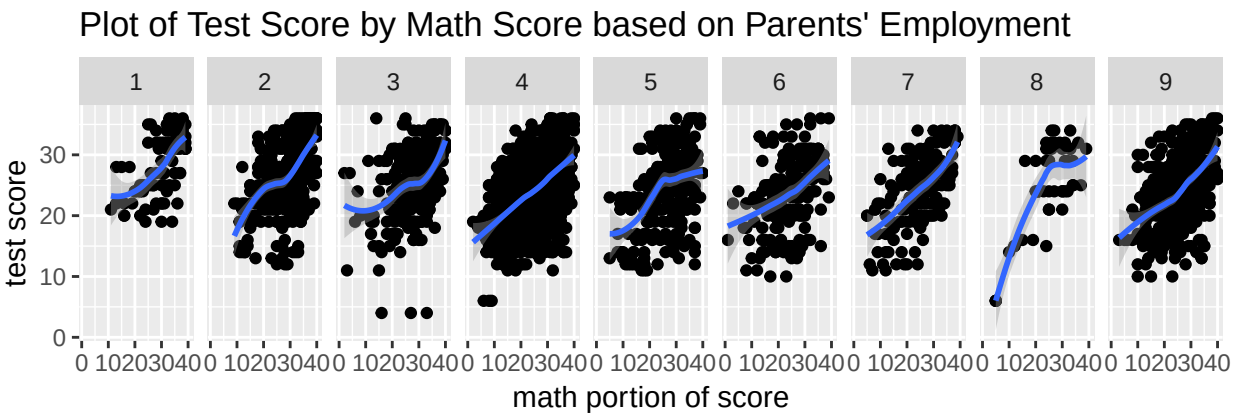
1. The first part of the analysis investigates the relationship between state test score (t.score) and English portion of the score (english) vs. the relationship between state test score (t.score) math potion of the score (math).

Initially, it appears that the relationship is consistent across test portion. Specifically, a higher English score is associated with a higher test score, a higher math score is associated with a higher test score, and both relationships appear linear. (It is worth nothing that the LOESS model does not fit well, and log-transformation is recommended.) However, when parents' employment type is controlled for, it appears that the relationship is not consistent across test portion. For example, when both parents are non-manual labors (employ=4), the relationship appears consistent. On the other hand, when both parents are currently employed (employ=8), one relationship appears polynomial, and the other appears logarithmic.


Plot of Test Score by English Score
test score
30
20
10
0
25
50
75
100
English portion of score


Plot of Test Score by Math Score
test score
30
20
10
0
10
20
30
40
math portion of score


Plot of Test Score by English Score based on Parents' Employment
1
2
3
4
5
6
7
8
9
test score
40
30
20
10
0 25 50 75 100
English portion of score


Plot of Test Score by Math Score based on Parents' Employment
1
2
3
4
5
6
7
8
9
test score
30
20
10
0
0 10 20 30 40
math portion of score

```
##
## Call:
## lm(formula = t.score ~ english)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -21.3717  -3.4553   0.2956   3.8827  13.3744
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 19.977539   0.217829   91.71   <2e-16 ***
## english      0.098075   0.003755   26.12   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.277 on 3234 degrees of freedom
## Multiple R-squared:  0.1742, Adjusted R-squared:  0.174
## F-statistic: 682.3 on 1 and 3234 DF,  p-value: < 2.2e-16
```

```
##
## Call:
## lm(formula = t.score ~ math)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -23.6481  -3.2603   0.3316   3.5458  15.9133
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 14.51510    0.31592   45.95   <2e-16 ***
## math         0.39797    0.01139   34.94   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.948 on 3234 degrees of freedom
## Multiple R-squared:  0.274,  Adjusted R-squared:  0.2738
## F-statistic:  1221 on 1 and 3234 DF,  p-value: < 2.2e-16
```

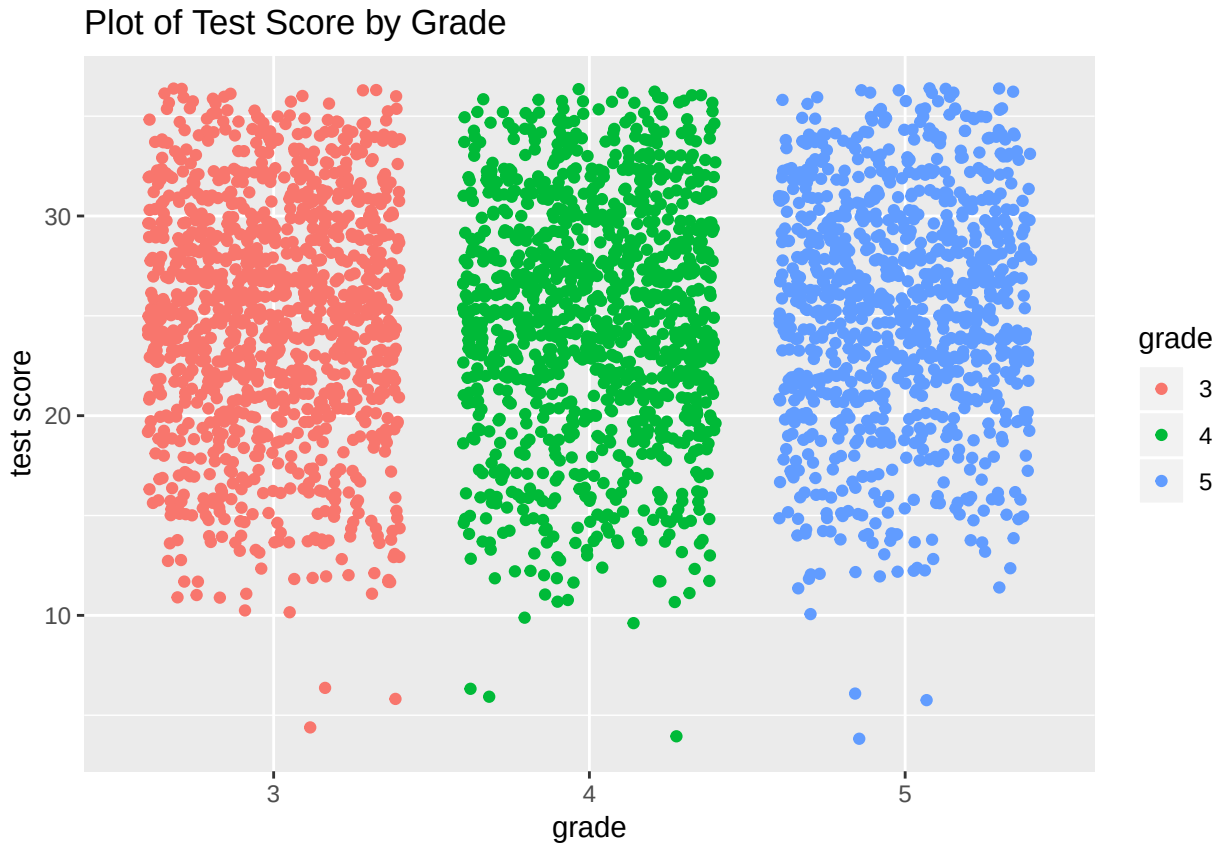
```
## Anova Table (Type III tests)
##
## Response: t.score
##             Sum Sq   Df   F value    Pr(>F)
## (Intercept)  40089    1 1462.3065 < 2.2e-16 ***
## english      15772    1  575.3048 < 2.2e-16 ***
## employ        1624    8    7.4054 8.154e-10 ***
## Residuals    88441 3226
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

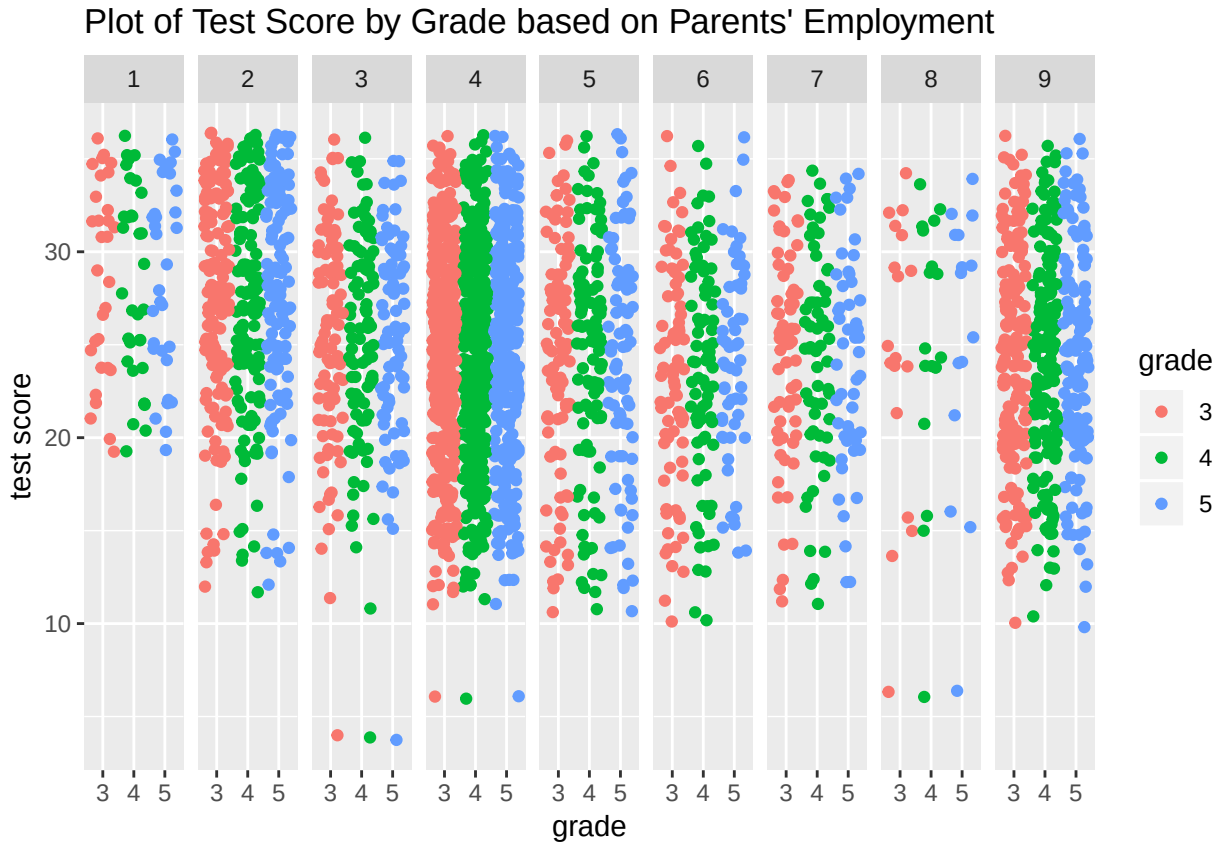
```
## Anova Table (Type III tests)
##
## Response: t.score
##             Sum Sq   Df   F value    Pr(>F)
## (Intercept)  18683    1  775.4661 < 2.2e-16 ***
## math         26490    1 1099.5289 < 2.2e-16 ***
```

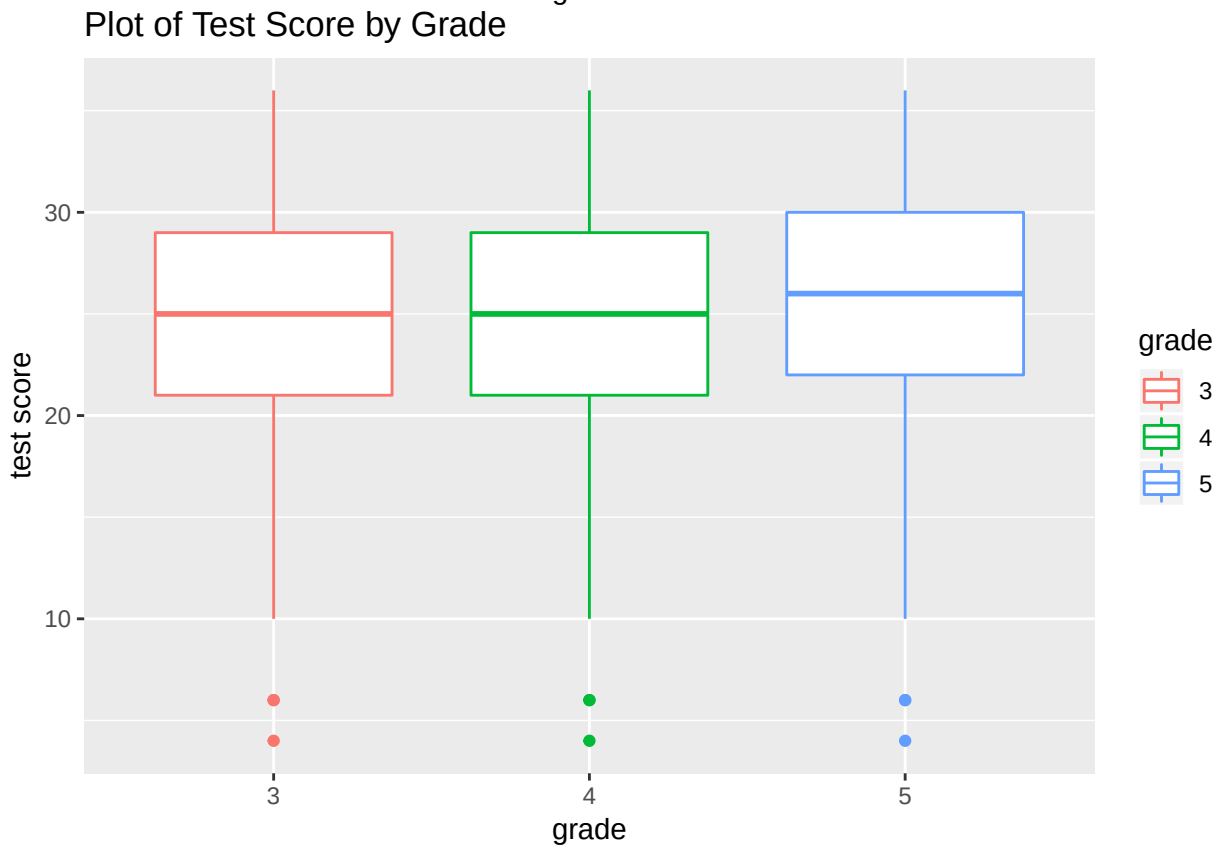
```
## employ        1459    8    7.5721 4.514e-10 ***
## Residuals    77722 3226
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

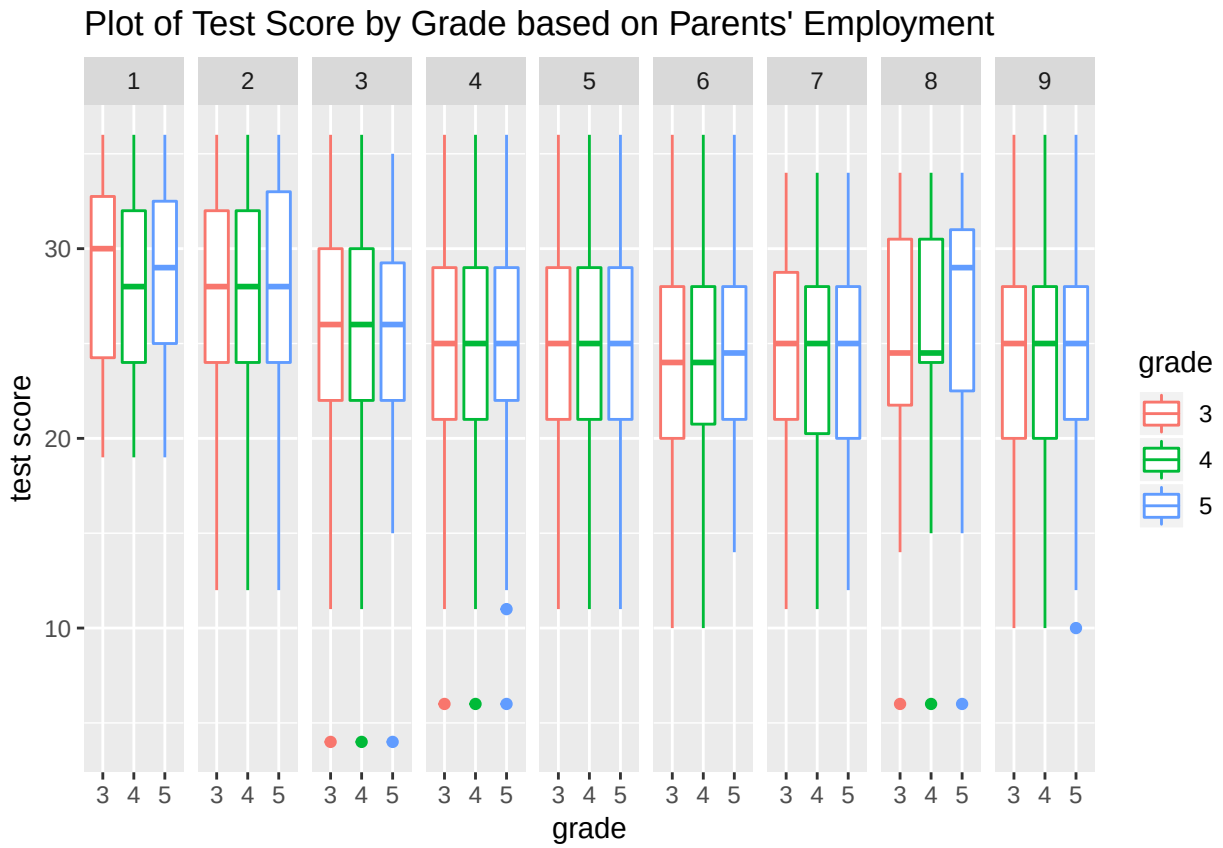
2. The second part of the analysis investigates the relationship between state test score (t.score) and student's grade (grade).

Initially, it appears that there is significant mean difference for at least one test score (p=0.4244). However, when parents' employment type is controlled for, it appears that there is no significant mean difference in test scores (p=0.5039). For example, when both parents are currently employed (employ=8), although the boxplot shows that mean test score for grade 5 is significantly higher than mean test score for grade 3 and that for grade 4, it is only because this group has sparse data.




Plot of Test Score by Grade based on Parents' Employment
1
2
3
4
5
6
7
8
9
test score
30
20
10
3 4 5
grade
grade
3
4
5


Plot of Test Score by Grade
test score
30
20
10
3
4
5
grade
grade
3
4
5



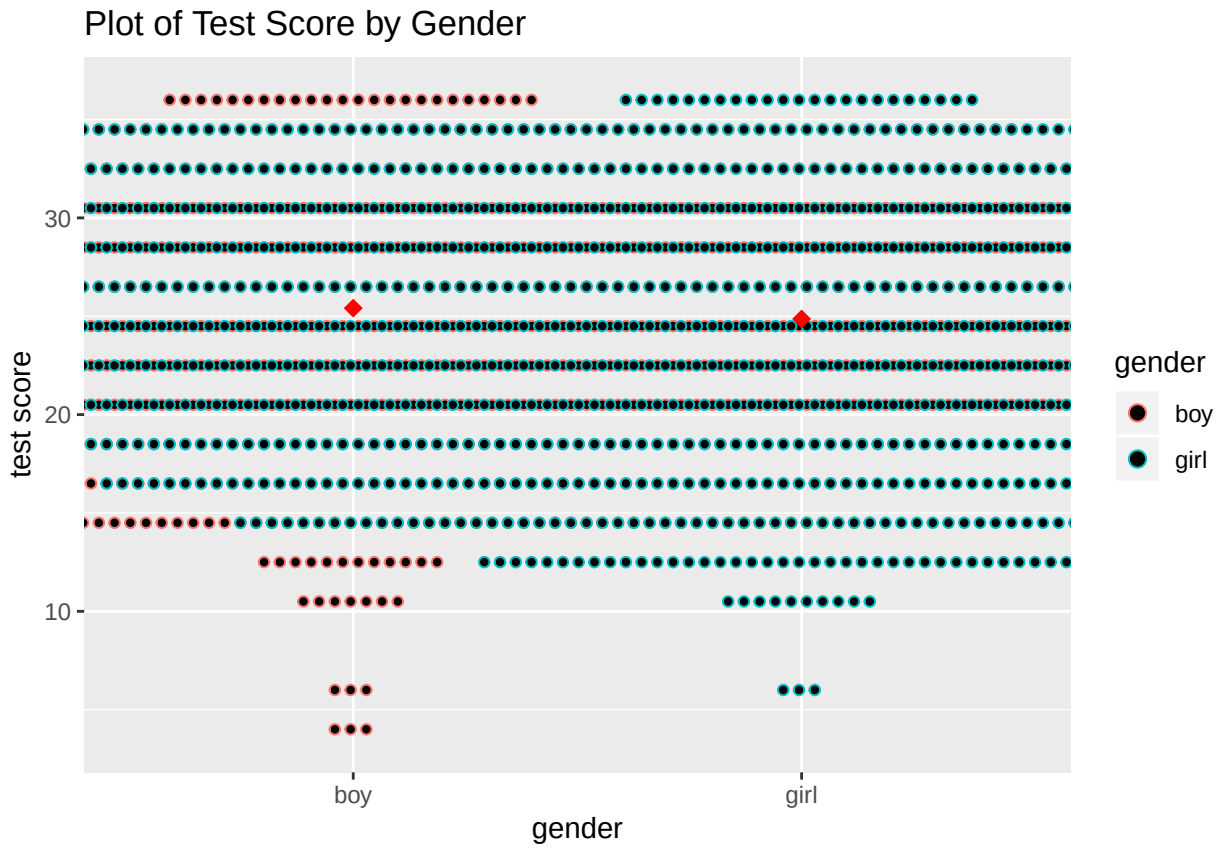

```
## Anova Table (Type III tests)
##
## Response: t.score
##             Sum Sq   Df    F value Pr(>F)
## (Intercept) 723652    1 21461.9483 <2e-16 ***
## grade           58    2     0.8573 0.4244
## Residuals   109010 3233
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Anova Table (Type III tests)
##
## Response: t.score
##             Sum Sq   Df   F value Pr(>F)
## (Intercept)  71747    1 2221.2322 <2e-16 ***
## grade           44    2    0.6855 0.5039
## employ        4841    8   18.7357 <2e-16 ***
## Residuals   104169 3225
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3. The third part of the analysis investigates the relationship between state test score (t.score) and student's gender (gender).

Initially, it appears that there is significant mean difference for at least one test score (p= 0.007251 **). When parents' employment type is controlled for, it appears that there is significant mean difference in test scores (p= 0.001711 **). For example, when both parents are currently employed (employ=8), the spreads are clearly different.

```
## `stat_bindot()` using `bins = 30`. Pick better value with `binwidth`.
```




```
## `stat_bindot()` using `bins = 30`. Pick better value with `binwidth`.
```


```
## Anova Table (Type III tests)
##
## Response: t.score
##               Sum Sq   Df    F value    Pr(>F)
## (Intercept) 1001537    1 29763.1545 < 2.2e-16 ***
## gender          243    1     7.2189  0.007251 **
## Residuals    108825 3234
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Anova Table (Type III tests)
##
## Response: t.score
##              Sum Sq   Df  F value    Pr(>F)
## (Intercept)  75936    1 2357.852 < 2.2e-16 ***
## gender         317    1    9.853  0.001711 **
## employ        4929    8   19.132 < 2.2e-16 ***
## Residuals   103896 3226
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

III. RESULTS

It appears that it is not necessarily the case that the higher the English portion or the math portion of the score is, the higher the overall state test score is. In addition, it appears that parents' employment type is a confounding variable, whether the model uses grade or gender as the main predictor of interest. It is also possible that parents' employment type interacts with one or more variables. Further studies should attempt

to fit separate model 1) using English portion of the score as the response to test, 2) using math portion of the score as the response to test, 3) using parents' employment type as the main predictor of interest, and 4) allowing for interaction to see if the effect of one variable on the response variable depends on the other variable, and vice versa.