PISA2012_wenchit

Abstract

In this research, I want to explore whether there is a discrepancy among scores in mathematic literacy within Australia. For insatnce, comparing the education resources between remote and city areas and the discrepancies between private or public schools. Based on the PISA2012 mathematics literacy survey data using statistical analysis like linear regression model and ANOVA test. Also, I will try to break down the relationship between school location and how it affects the scores in math literacy, the relationship between private or public schools and how it relates to the students' scores in math literacy.

Introduction

- PISA2012: the term PISA stands for Programme for International Student Assessment is a survey that randomly select 15 year-old students(students who are attending secondary schools) as samples for assessment. In 2012, a total of 65 OECD countries and economics and about half a million 15 year-old students participated in the PISA assessment. Generally, the assessed reaults lies in 5 categories: Level 5 are high performers, whereas students who lies below the international standard baseline level 2 are cosidered low performers. In 2012, 775 Australian schools and 14,481 students participated in this assessment. To ensure the authenticity, an amount of indigenous students were also sampled.
- Students are categorized in 6 different levels in accordance to their proficiency in the assessment(PISA, 2012):
- Level 6: Students who score higher than 669.3 scores belongs to level6.
- Level 5: Students who score higher than 607.0 scores belongs to level5.
- Level 4: Students who score higher than 544.7 scores belongs to level4.
- Level 3: Students who score higher than 482.4 scores belongs to level3.
- Level 2: Students who score higher than 420.1 scores belongs to level2.
- Level 1: Students who score higher than 357.8 scores belongs to level1.
- Below 1: not demonstrate even the most basic types of mathematical literacy that PISA measures. These students are likely to be seriously disadvantaged in their lives beyond school.
- Mathematic Literacy: in the mathematic literacy domain, the assessment focused on students' ability to solve mathematic problems described in a real-life situation. In PISA2012 framework, it defined mathematic literacy as follows: "Mathematic literacy is an individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically nd using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that Mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens."

The assessment in math literacy is designed according three main components:

1. the context of a challenge or problem that arises in the real world
2. the nature of mathematical thought and action that can be used to solve the problem
3. the processes that the problem solver can use to construct a solution.

Overview of Australian Education System:

–Terms and definition It is defined in the handbook from PISA that, Village School or Rural Area: less than 3,000 people Small Town School: 3,000 to about 15,000 people Town School: 15,000 to about 100,000 people City School: 100,000 to about 1,000,000 people, for example, Hobart, Tasmania Large City School: ith over 1,000,000 people, for example, Sydney and Melbourne

–Facts of Australian Education 1. In 2016, there are over 9,400 schools in which 1400 of them are secondary schools across Australia. Which means more than half of the amount of secondary schools were participants of PISA2012 assessment.

2. In 2016, there are over 6,000 government(public) schools, more than 1700 Catholic schools(private) and more than 1,000 independent schools(private)
3. In 2017, around 65% of students attended government school, 19% students attended Catholic schools and 16% students attended independent schools.
4. In 2014, the proportion of residents aged between 25~34 years old who has a degree was: Major City 42.2 %, Inner Regional 21.8%, Outer Regional 19.5%, and Remote and Very Remote 17.8%.

Regarding the facts mentioned above, I want to provide

Methods Used

– Libraries used

1. ggplot2: for plot generation (Wickham 2009)
2. PISA2012lite: original data set (Biecek, n.d.)
3. lme4: for linear regression analysis (Bates et al. 2015)
4. magrittr: for specified functions such as %>% (Bache and Wickham 2014)
5. data.table: (Dowle and Srinivasan 2017)
6. dplyr: to enable select function (Wickham et al. 2017)

– PISA2012 data In this analysis, the original dataset is provided by library The PISA2012lite dataset contains 10 data tables, including the survey result of school questionnaire and parent questionnaire, plus the student's questionnaire and assesment result. Including 775 Australian schools and 14,481 students participated. Indegi I used the 5 plausible values(PV1Math~PV5MATH) for as the measure of a student's mathematical literacy. The minimum score in this assessment is 0 and maximum is 1,000. For reliability, smaller states and indigenous students were oversampled in this assessment.

Linear Regression Analysis:

ANOVA Test:

Tukey Test:

Results

```
library(data.table)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:data.table':
##
##     between, first, last
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

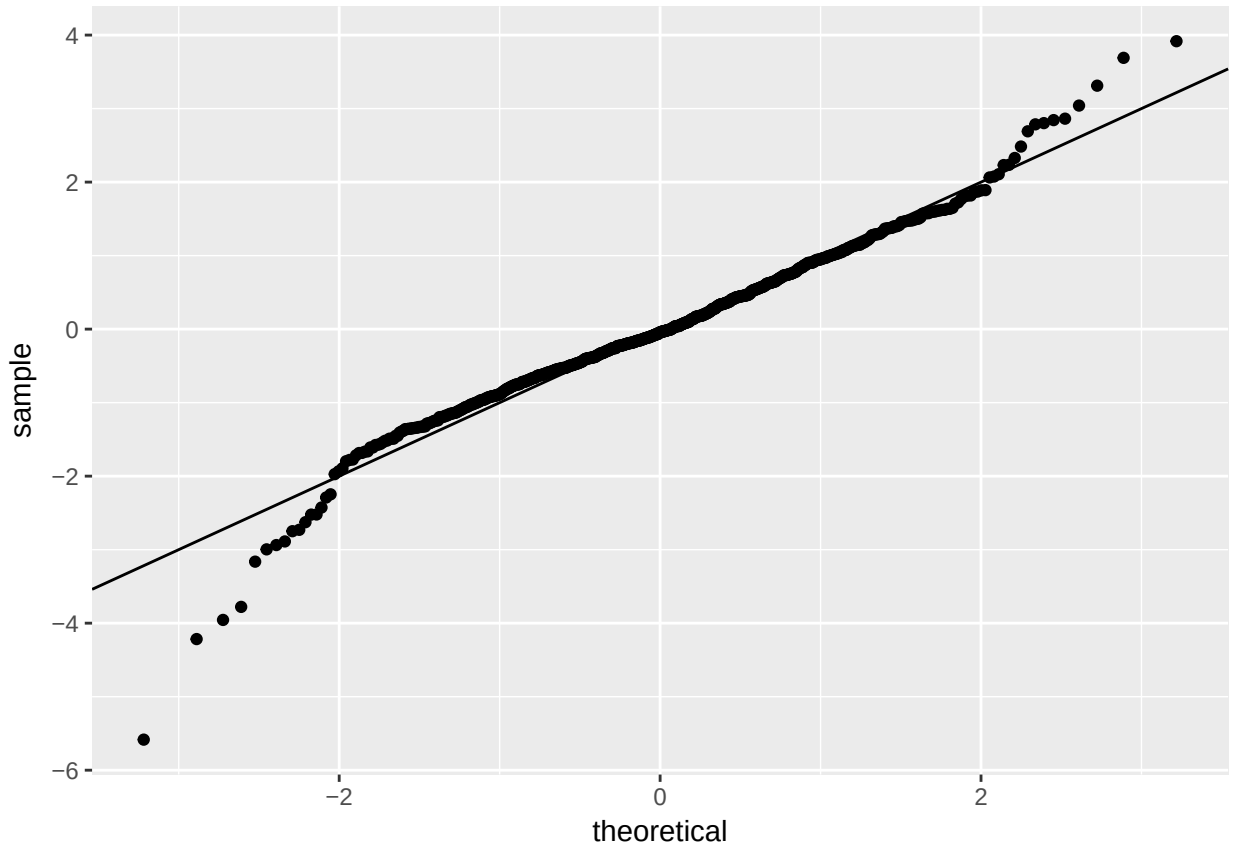
```
library(ggplot2)
library(PISA2012lite)
library(lme4)
```

```
## Loading required package: Matrix
```

```
library(magrittr)
data("school2012")
setDT(school2012)
data("computerStudent2012")
setDT(computerStudent2012)

#calculate the weighted average of the Math Literacy performance using PV1MATH to PV5MATH
pv_cols <- paste0("PV", 1:5, "MATH")
student_data <- computerStudent2012[NC == "Australia",
                                    lapply(.SD, weighted.mean, w = W_FSTUWT / sum(W_FSTUWT)),
                                    by = SCHOOLID, .SDcols = c(pv_cols, "ESCS") ][, .(SCHOOLID, ESCS,
                                                                                      Mean_PVMATH = Reduce(`+`, .SD) /
                                                                                      .SDcols = pv_cols]
#a summary table showing the overall mean math score
student_data[,  .(mu = mean(Mean_PVMATH, na.rm = T), sigma = sd(Mean_PVMATH, na.rm = T))]
```

```
##          mu    sigma
## 1: 495.5452 59.07824
```

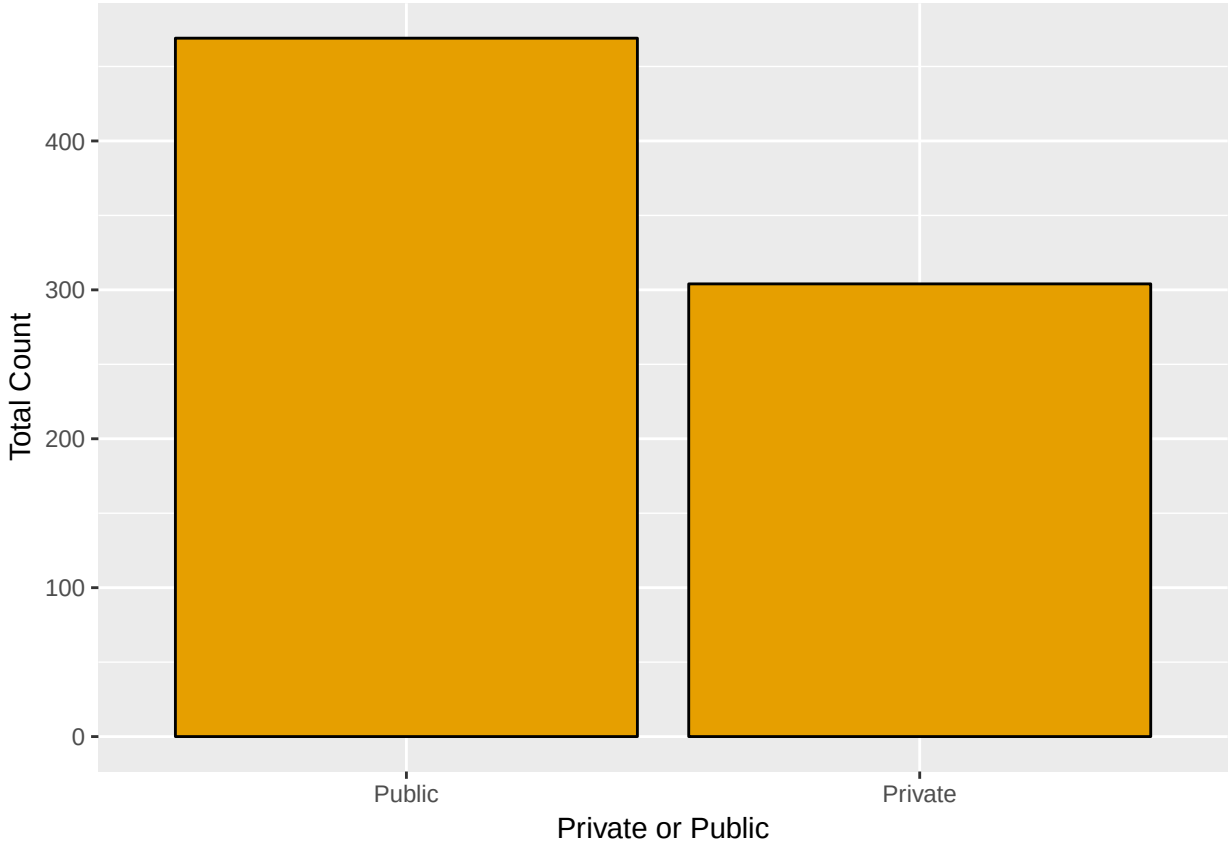
```
#test whether the data is normally distributed
#' Put data onto a standard normal scale
#' @param x A numeric vector
#' @return A numeric vector of same length as `x`. This vector has mean 0 and sd 1.
standardise <- function(x) {
  (x - mean(x)) / sd(x)
}

#a plot test for normality
ggplot(student_data) + stat_qq(aes(sample = Mean_PVMATH %>% standardise)) + geom_abline()
```



As we can see from the plot above, the column Mean_PVMATH is normally distributed. Thereby, we can proceed to the statistical test we are going to perform in the following paragraph.

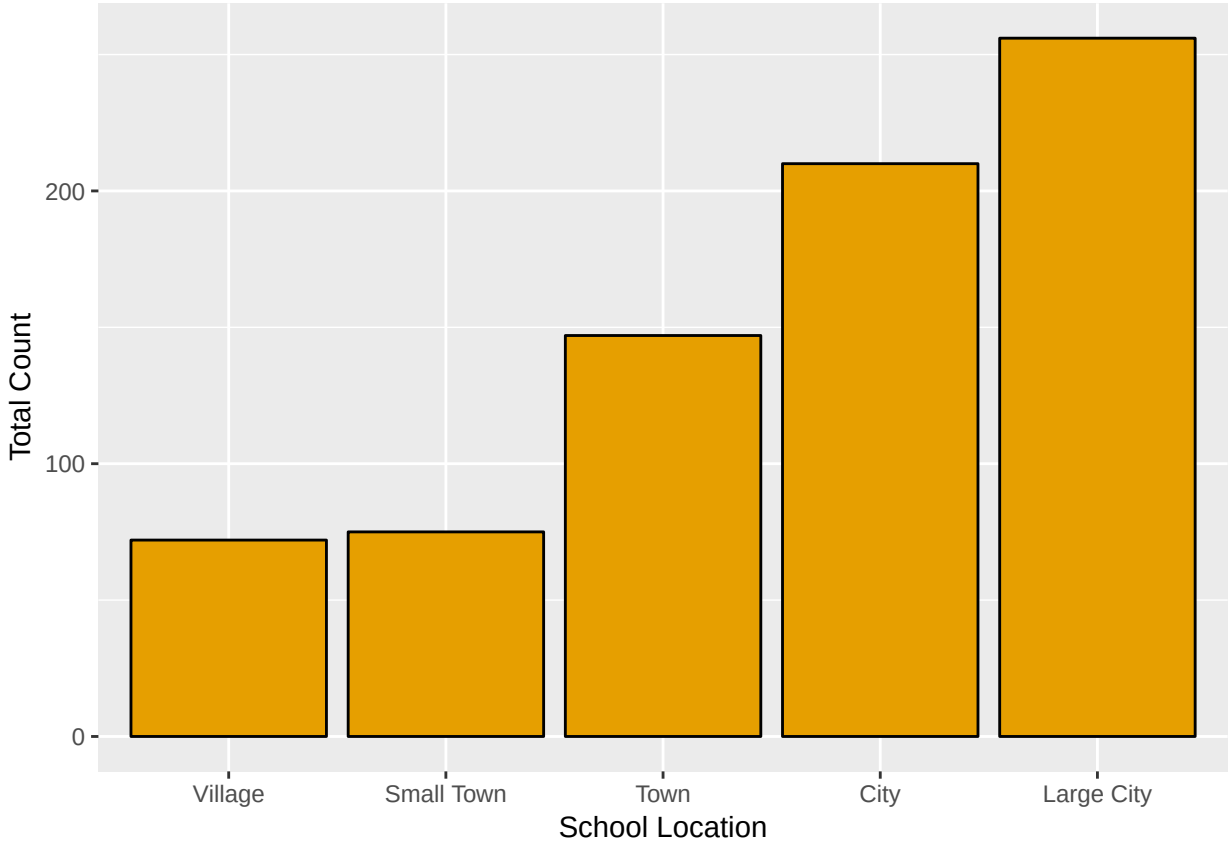
The following graph shows the amount of private and public schools in Australia that participated:

```
#plot a bar chart showing the count of private and public schools participated
ggplot(school2012[NC == "Australia" & !is.na(SC01Q01)], aes(x=SC01Q01))+geom_bar(fill="#E69F00", colour=
```



The following is a graph about the distribution of schools in Australia that participated:

```
#plot bar chart showing the school location for schools participated:
ggplot(school2012[NC == "Australia" & !is.na(SC03Q01)], aes(SC03Q01))+geom_bar(fill="#E69F00", colour="
```



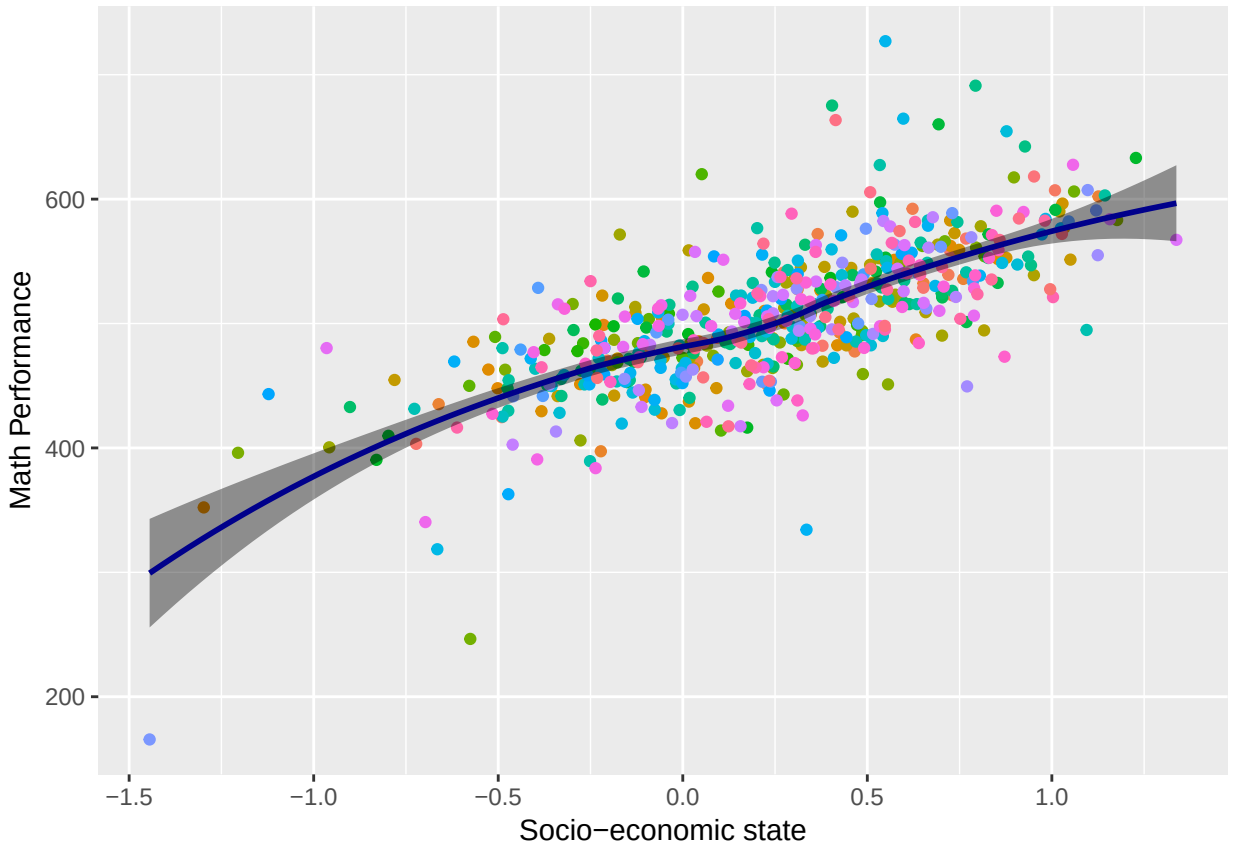
The following cosidering the socio-economic state of the student using Mean_PVMATH:

```
#a point plot showing the relationship between socio-economic state and math performance
ggplot(data = student_data, aes(x = ESCS, y = Mean_PVMATH)) +
  geom_point(aes(colour = SCHOOLID)) + geom_smooth(fill="black", colour="darkblue", size=1)+ theme(leger
```

```
## `geom_smooth()` using method = 'loess'
```

```
## Warning: Removed 234 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 234 rows containing missing values (geom_point).
```



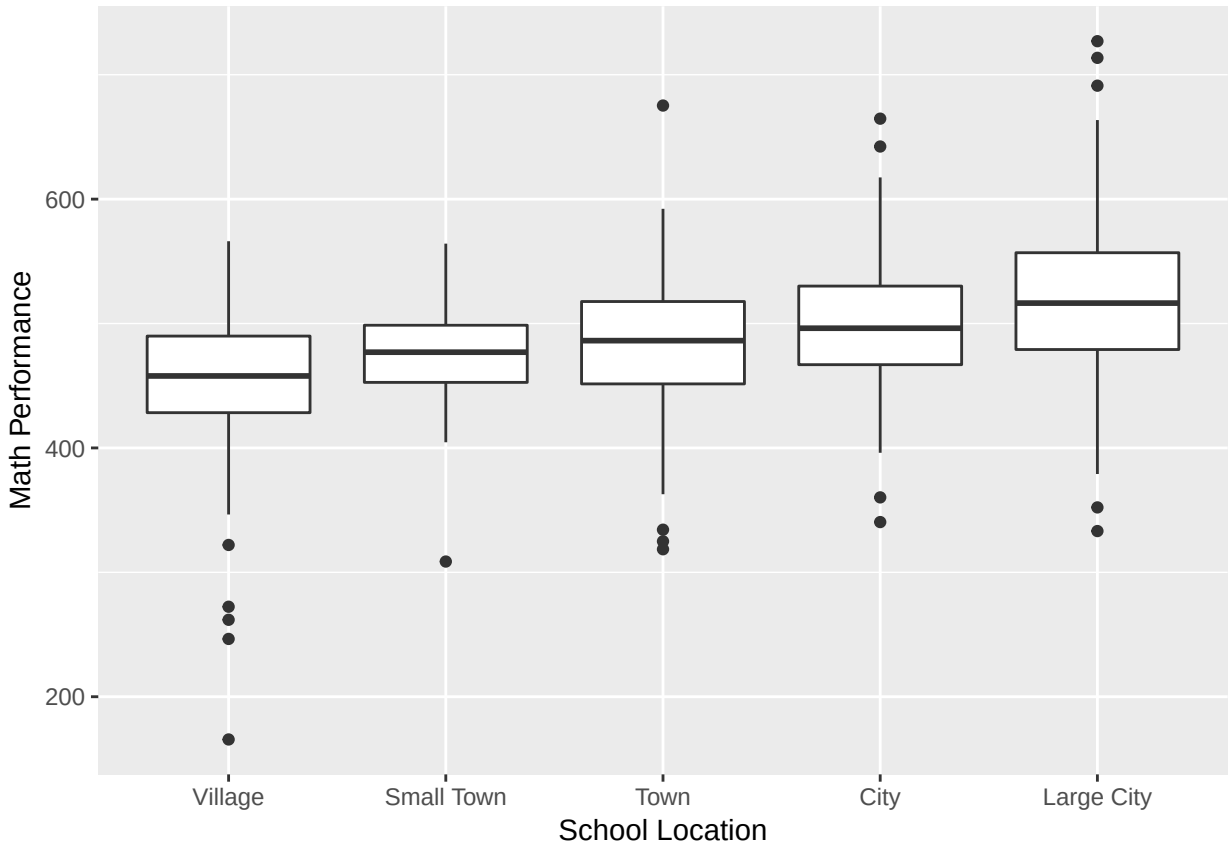
The graph shows a positive relationship between socio-economic state of a student and their math performance.

Now we want to look into the relationship between schools and weighted math performances from PV1MATH to PV5MATH:

```
#filter out the data from Australia and select column SC03Q01(School location) and SchoolID
school_view <- school2012[NC =="Australia" & !is.na(SC03Q01)]
school_plot_data <- select(school_view, SC03Q01, SCHOOLID)

#merge two tables into one table for plotting use
plot_data <- merge(student_data, school_plot_data, by="SCHOOLID")

#a simple summary table
plot_data[, .(mu = mean(Mean_PVMATH, na.rm = T),
              sigma = sd(Mean_PVMATH, na.rm = T)),
              by = SC03Q01]
```

```
##       SC03Q01       mu    sigma
## 1:       Town 484.0591 52.41388
## 2: Large City 518.5862 60.02301
## 3:       City 500.7306 49.46786
## 4:    Village 448.4095 69.54368
## 5: Small Town 472.2424 40.09360
```

```
#merge two tables: student_data and school_plot_data and create a boxplot
ggplot(plot_data, aes(x=factor(SC03Q01), y=Mean_PVMATH))+geom_boxplot()+labs(x="School Location", y="Ma
```




```
#run linear regression test
fit <- lm(Mean_PVMATH~SC03Q01, data=plot_data)
summary(fit)
```

```
##
## Call:
## lm(formula = Mean_PVMATH ~ SC03Q01, data = plot_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -282.773  -34.668    0.743   35.401  208.365
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)        448.410      6.496  69.033  < 2e-16 ***
## SC03Q01Small Town   23.833      9.094   2.621  0.00895 **
## SC03Q01Town         35.650      7.928   4.497 7.99e-06 ***
## SC03Q01City         52.321      7.527   6.951 7.85e-12 ***
## SC03Q01Large City   70.177      7.352   9.545  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 55.12 on 755 degrees of freedom
## Multiple R-squared:  0.1362, Adjusted R-squared:  0.1316
## F-statistic: 29.76 on 4 and 755 DF,  p-value: < 2.2e-16
```

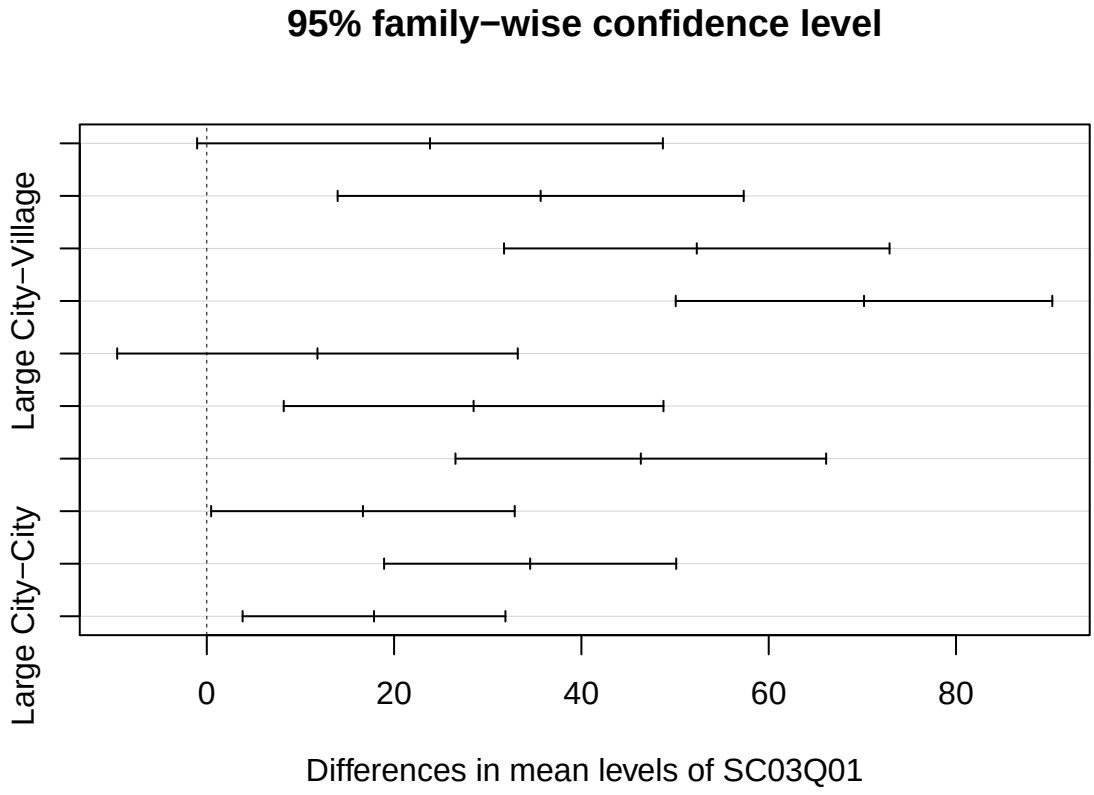
```r
#run ANOVA test
plot_anova <- aov(Mean_PVMATH~SC03Q01, data = plot_data)
summary(plot_anova)
```

```
##              Df  Sum Sq Mean Sq F value Pr(>F)
## SC03Q01       4  361608   90402   29.76 <2e-16 ***
## Residuals   755 2293569    3038
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#run Tukey test
tuk <- TukeyHSD(plot_anova)
tuk
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Mean_PVMATH ~ SC03Q01, data = plot_data)
##
## $SC03Q01
##                            diff        lwr      upr     p adj
## Small Town-Village    23.83292 -1.0329231 48.69877 0.0676216
## Town-Village          35.64960 13.9706366 57.32857 0.0000781
## City-Village          52.32112 31.7389970 72.90324 0.0000000
## Large City-Village    70.17664 50.0721922 90.28109 0.0000000
## Town-Small Town       11.81668 -9.5692727 33.20264 0.5556866
## City-Small Town       28.48819  8.2149344 48.76145 0.0012437
## Large City-Small Town 46.34372 26.5555839 66.13185 0.0000000
## City-Town             16.67151  0.4643414 32.87868 0.0402473
## Large City-Town       34.52704 18.9309607 50.12311 0.0000000
## Large City-City       17.85552  3.8240010 31.88704 0.0048120
```

```r
plot(tuk)
```

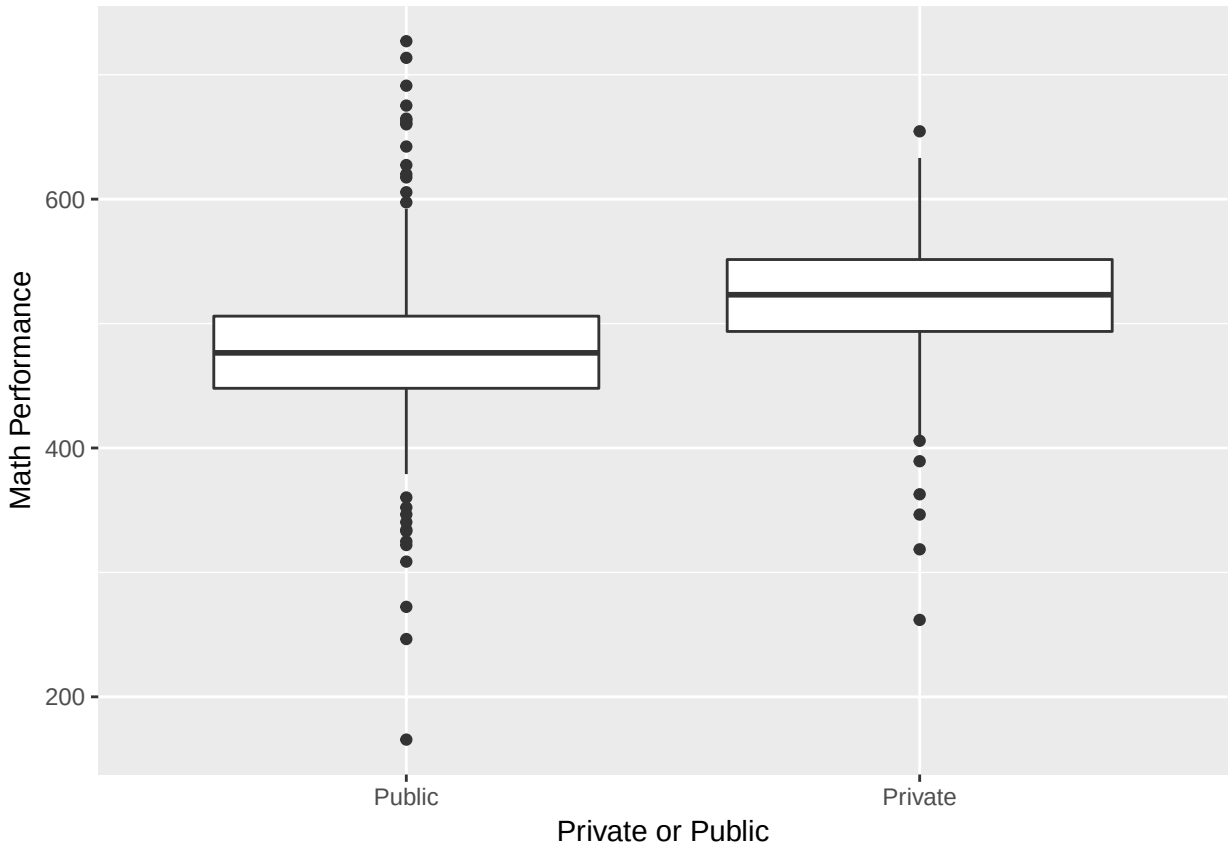


The boxplot shows there is a significant difference in the mean score of students from different region of Australia. The graph implies that students from large city in Australia, for example, Sydney and Melbourne normally scores higher than students from a village. Those pairs that are significantly different according to to result of Tuckey test are those that does not across the 0 value.

```
school_view <- school2012[NC =="Australia" & !is.na(SC01Q01)]
school_plot_data <- select(school_view, SC01Q01, SCHOOLID)

#merge two tables into one table for plotting use
plot_data <- merge(student_data, school_plot_data, by="SCHOOLID")

#a simple summary table
plot_data[, .(mu = mean(Mean_PVMATH, na.rm = T),
              sigma = sd(Mean_PVMATH, na.rm = T)),
              by = SC01Q01]
```

```
##    SC01Q01       mu    sigma
## 1: Private 521.0669 49.04944
## 2:  Public 479.2423 59.25269
```

```
#create a boxplot comparing the mean value
ggplot(plot_data, aes(x=factor(SC01Q01), y=Mean_PVMATH))+geom_boxplot()+labs(x="Private or Public", y="
```




```
#run linear regression test
fit <- lm(Mean_PVMATH~SC01Q01, data=plot_data)
summary(fit)
```

```
##
## Call:
## lm(formula = Mean_PVMATH ~ SC01Q01, data = plot_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -313.605  -29.561    0.133   28.136  247.709
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)     479.242      2.561  187.11   <2e-16 ***
## SC01Q01Private   41.825      4.084   10.24   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 55.47 on 771 degrees of freedom
## Multiple R-squared:  0.1197, Adjusted R-squared:  0.1186
## F-statistic: 104.9 on 1 and 771 DF,  p-value: < 2.2e-16
```

```
#run ANOVA test
plot_anova <- aov(Mean_PVMATH~SC01Q01, data = plot_data)
summary(plot_anova)
```

```
##              Df  Sum Sq Mean Sq F value Pr(>F)
```

```
## SC01Q01       1  322649  322649   104.9 <2e-16 ***
## Residuals   771 2372064    3077
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The boxplot shows there is a great difference in the mean score of students from different sectors of Australia. The graph implies that students from private schools in Australia outperform the students from government/public schools.

Discussion

According to the school location analysis, we can tell that there is a positive relationship between the school location and the student's math literacy score. The mean score for all Australian students is 495.5, whereas the students from a village is 448.41, mean score for students from a large city is 518.59. The difference between mean scores is (518.59-448.41)=70.18 points.

According to the private/public analysis, we can tell that there is a positive relationship between whether the student enters a private or public/government school is a factor that is affecting their PISA mathematical literacy assessment. While the mean score for all Australian students is 495.5, the mean score for students from independent/private sector is 521.067, mean score for students who attend in public/government school is 479.2. The difference is (521.067-479.2)= 41.87 points. In the linear regression test from the private/public test, the p values are all smaller than 0.05 which implies that the whether the school is a private on or public one is highly related to a student's math performance. In the ANOVA test, the F value is 104.9 and p-value is very small(less than 0.05). Suggesting that there is a strong relationship between whether a school is private or public can affect the student's score on math literacy. Since there are only two levels of factors in this test, we will not run a Tukey test like above.

In the linear regression test for school location, the p values are all smaller than 0.05 which implies that the store locations are highly related to a student's math performance. In the ANOVA test, the F value is 29.76 and p-value is very small(less than 0.05). Which implies that there is a significant relationship between the school location and the scores in students' math literacy. And since there are multiple(more than 2) factors in this dataset, we will run another tukey test to compare the differences between each paired groups.

From the Tukey test above, telling from the column diff and p adj, these facts can be able to conclude:

1. There is no significant discrepancy in performances between a Town school and a Small Town School since the p=0.55>0.05 and Small Town-Village since p=0.07>0.05.
2. There are significant discrepancy in math performace between City-Village, Large City-Village, Large City-Samll Town, Large City-Town, since the p value all equal to 0. These significant difference is shown in the plotted Tukey graph.

Conclusion

A few results can be concluded accroding to the analysis result:

1. Students from private/independent schools significantly outperform public/government students.
2. Students from large city outperform students from other scetors of students.
3. Students with a higher socio-economic state also show a higher level of proficiency in math literacy.
4. Averagely, the result of all Australian students fall in level3 of proficiency.
5. Although the mean score for large city student's is highest among the but the standard deviation is a largest too, implying that the score distribution of large city students is wider than of other sectors.

To enable deeper investigation in the future, I think it's necessary that we incoporate data source from the Government of Education and try to analyze the discrepancy of education resources and funds distributed across the nation. This report can serve as an evidence to the analysis of equalization in education in the future.

Reference

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