Using the Illinois Report Card Data to Teach Statistics

MMC Conference of Workshops

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Contents

1 Variables

The ISBE raw data file *rx17.txt* contains 1,471 variables. The variable definitions are in the Excel file *RC17_layout.xlsx* and have been categorized into the groups shown below. The first number represents available variables in each group while the second is the number actually imported into the processed data file. The import script produces 316 variables from 20 of the 21 categories for all 3,796 Illinois public schools. (None of the NAEP variables were imported.) Usable files will be discussed in section 3.2.1.

School information (13 variables;12 imported)
Student demographics (396;71)
ACT (44;11)
Instructional setting (92;2)
Teacher and admin statistics (78;26)
District financial (67;40)
Region and legislative (3;2)
National Assmnt. of Educ. Progress (NAEP) (184;0)
College and Career readiness (16;3) CTE (4;1)
Advanced coursework (12;3)
AP courses (168;42)
IB courses (168;42)
Dual credit (168;42)
AP exams (36;12)
Post secondary remediation (4;1)
Response rate (5E survey) (4;2)
Health and wellness (3;1)
Teacher Attendance (4;1)
Teacher Evaluation (2;1)
School District Count (3;1)

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2 Descriptive Statistics via State Demographics

2.1 Categorical Count (Raw)

```
school_type <- rc17 %>%
  count(SCHOOL_TYPE_NAME, sort = TRUE) %>%
  mutate(rel_freq = n/sum(n))
school_type
```

```
## # A tibble: 4 x 3
##   SCHOOL_TYPE_NAME     n rel_freq
##   <chr>            <int>    <dbl>
## 1 ELEMENTARY        2406   0.634
## 2 HIGH SCHOOL        644   0.170
## 3 MIDDLE SCHL        604   0.159
## 4 CHARTER SCH        142   0.0374
```

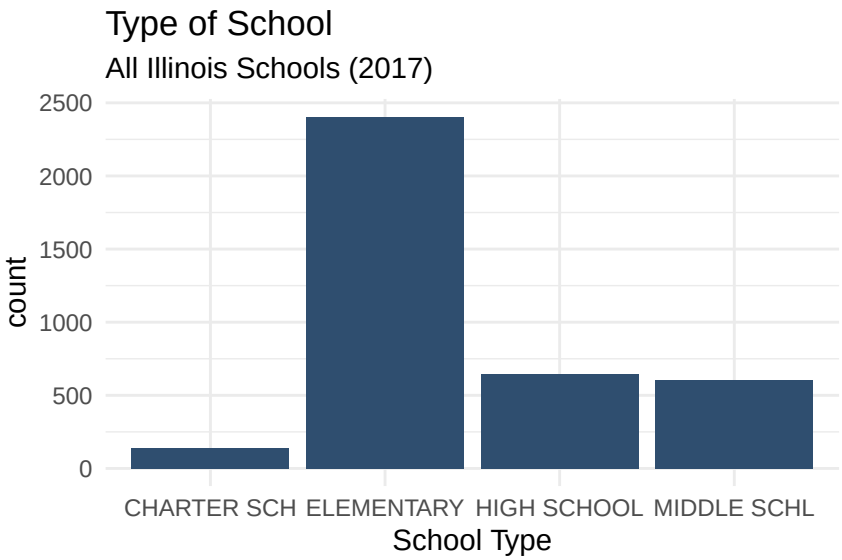
2.2 Categorical Count (Formatted)

```
kable(school_type) %>%
  kable_styling(bootstrap_options = "striped", full_width = F)
```

SCHOOL_TYPE_NAME	n	rel_freq
ELEMENTARY	2406	0.6338251
HIGH SCHOOL	644	0.1696523
MIDDLE SCHL	604	0.1591149
CHARTER SCH	142	0.0374078

2.3 Categorical Plot

```
ggplot(rc17, aes(x=factor(SCHOOL_TYPE_NAME)))+
  geom_bar(fill="#2F4E6F")+
  labs(title = "Type of School", x = "School Type", subtitle = "All Illinois Schools (2017)") +
  theme_minimal()
```

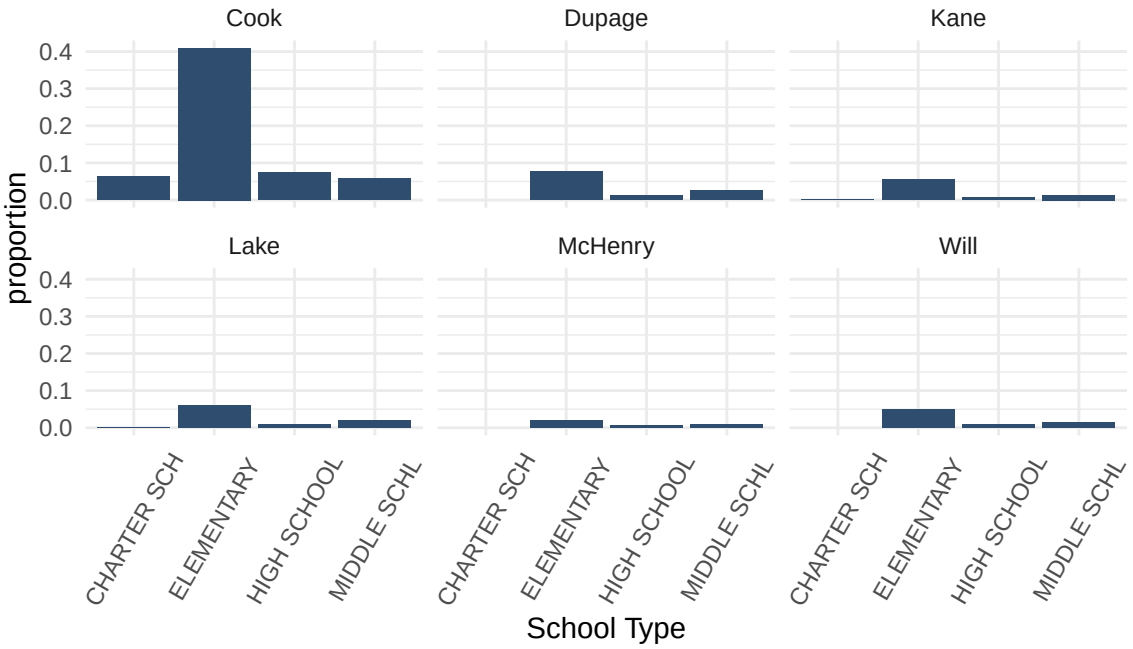


2.4 Categorical Analysis I

Write a short analysis for the types of schools in the state of Illinois.

2.5 Categorical Analysis II

```
rc17 %>%
filter(COUNTY == "Dupage" | COUNTY == "Will" | COUNTY == "Kane" |
         COUNTY == "Lake" | COUNTY == "Cook"| COUNTY == "McHenry") %>%
ggplot(aes(x=factor(SCHOOL_TYPE_NAME), y = (..count..)/sum(..count..))) +
  geom_bar(fill="#2F4E6F")+
  facet_wrap(~COUNTY, nrow = 2) +
  labs(title = "Type of School by County",
       x = "School Type",
       y = "proportion",
       subtitle = "Six Counties in the Chicago Metropolitan Region (2017)") +
  theme_minimal()  +
  theme(axis.text.x = element_text(angle = 60, vjust = 0.5))
```



Write a short analysis for the types of schools in the six county region.

3 Data Import

3.1 Data Files

3.1.1 Raw

The original raw data is available on the ISBE Report Card Data Library web page [https://www.isbe.net/Pages/Illinois-State-Report-Card-Data.aspx]. You will need to download both the fixed with data file (rc17.txt 2.4MB becomes 35.4MB) and the variable definitions (RC17_layout.xlsx). Use and/or modify import_rc17.txt [https://github.com/fbriody/MMC2020] to get a subset of the data into RStudio.

3.1.2 Six County Subset

A six county subset (2.7MB) is available [https://github.com/fbriody/MMC2020]. This file is ready to be used in R, Fathom or Excel.

3.1.3 Subsetting and Exporting

Creating the six county subset:

```
sixco <- rc17 %>%
  filter(COUNTY %in% c("Cook", "Lake", "Will", "Kane", "McHenry", "Dupage"))
```

Exporting the six county subset

```
write.csv(sixco,"sixco.csv", row.names = FALSE)
```

3.2 Using Fathom

3.2.1 Import

csv import attribute names

3.2.2 Displays

missing values and shift or option inspecting adding a third variable act v LowInc with school type

4 Numeric Summaries (REORDER THESE SECTIONS)

4.1 Lists

4.1.1 Number of High Schools in the Six County Region

```
sixco %>%
  filter(SCHOOL_TYPE_NAME == "HIGH SCHOOL") %>%
  group_by(COUNTY) %>%
  summarise(count = n())
```

```
## # A tibble: 6 x 2
##   COUNTY  count
##   <chr>   <int>
## 1 Cook      151
## 2 Dupage     23
## 3 Kane       16
## 4 Lake       21
## 5 McHenry    14
## 6 Will       17
```

4.1.2 Single List of Scores

```
mchenry_act <- rc17%>% filter(COUNTY == "McHenry", is.na(ACT_COMP_SCHOOL) == FALSE )
mchenry_act$ACT_COMP_SCHOOL
```

```
##  [1] 22.4 19.7 18.1 23.1 22.6 23.8 22.7 24.0 21.1 19.9 22.9 22.9 21.4 21.2
```

4.1.3 Single Values (MAYBE MOVE TO DATA IMPORT SECTION)

4.1.3.1 Finding a School

```
rc17 %>%
  filter(str_detect(SCHOOL_NAME, "Morton")) %>%
  select(SCHOOL_ID, SCHOOL_NAME, ACT_COMP_SCHOOL)
```

```
## # A tibble: 7 x 3
##   SCHOOL_ID       SCHOOL_NAME                    ACT_COMP_SCHOOL
##   <chr>           <chr>                                    <dbl>
```

```
## 1 060162010170001 J Sterling Morton East High Sch            18.4
## 2 060162010170002 J Sterling Morton West High Sch            18.7
## 3 060162010170003 J Sterling Morton Freshman Cntr            NA
## 4 070161450022004 Morton Gingerwood Elem School              NA
## 5 150162990252844 Morton Elem Career Academy                 NA
## 6 530907090260006 Morton High School                         23.3
## 7 530907090261005 Morton Jr High School                      NA
```

4.1.3.2 Using a Filter

```
prospect <- rc17 %>%
  filter(str_detect(SCHOOL_NAME, "Prospect High School"))
prospect_act <- prospect$ACT_COMP_SCHOOL
prospect_act
```

```
## [1] 25
```

4.1.3.3 Using a Function

```
phs_value <- function(unk) {
  x <- rc17 %>%
    filter(SCHOOL_ID == "050162140170005")
  x[unk]
}

phs_value("ACT_COMP_SCHOOL")
```

```
## # A tibble: 1 x 1
##   ACT_COMP_SCHOOL
##             <dbl>
## 1              25
```

4.1.4 Lake County ACT Scores (Ordered and Formatted)

```
lake_ACT <- rc17 %>%
  filter(SCHOOL_TYPE_NAME == "HIGH SCHOOL", COUNTY == "Lake") %>%
  arrange(desc(ACT_COMP_SCHOOL)) %>%
  select(COUNTY, SCHOOL_NAME, ACT = ACT_COMP_SCHOOL)
kable(lake_ACT)
```

Table 1: Types of School Districts

	Dupage	Lake
LARGE	182	150
MEDIUM	52	38
SMALL	0	4

COUNTY	SCHOOL_NAME	ACT
Lake	Adlai E Stevenson High School	26.9
Lake	Deerfield High School	26.4
Lake	Lake Forest High School	26.3
Lake	Libertyville High School	25.9
Lake	Highland Park High School	25.2
Lake	Vernon Hills High School	25.1
Lake	Lake Zurich High School	24.9
Lake	Barrington High School	24.8
Lake	Grayslake Central High School	23.3
Lake	Lakes Community High School	22.6
Lake	Grayslake North High School	22.4
Lake	Warren Township High School	22.1
Lake	Wauconda High School	21.8
Lake	Antioch Comm High School	21.7
Lake	Mundelein Cons High School	21.4
Lake	Grant Community High School	21.3
Lake	New Tech High - Zion-Benton East	20.1
Lake	Zion-Benton Twnshp Hi Sch	18.6
Lake	Waukegan High School	17.9
Lake	Round Lake Senior High School	17.8
Lake	North Chicago Community High Sch	17.5

Create a boxplot for Lake County ACT scores. How could you compare to DuPage county?

4.2 Two-Way Tables

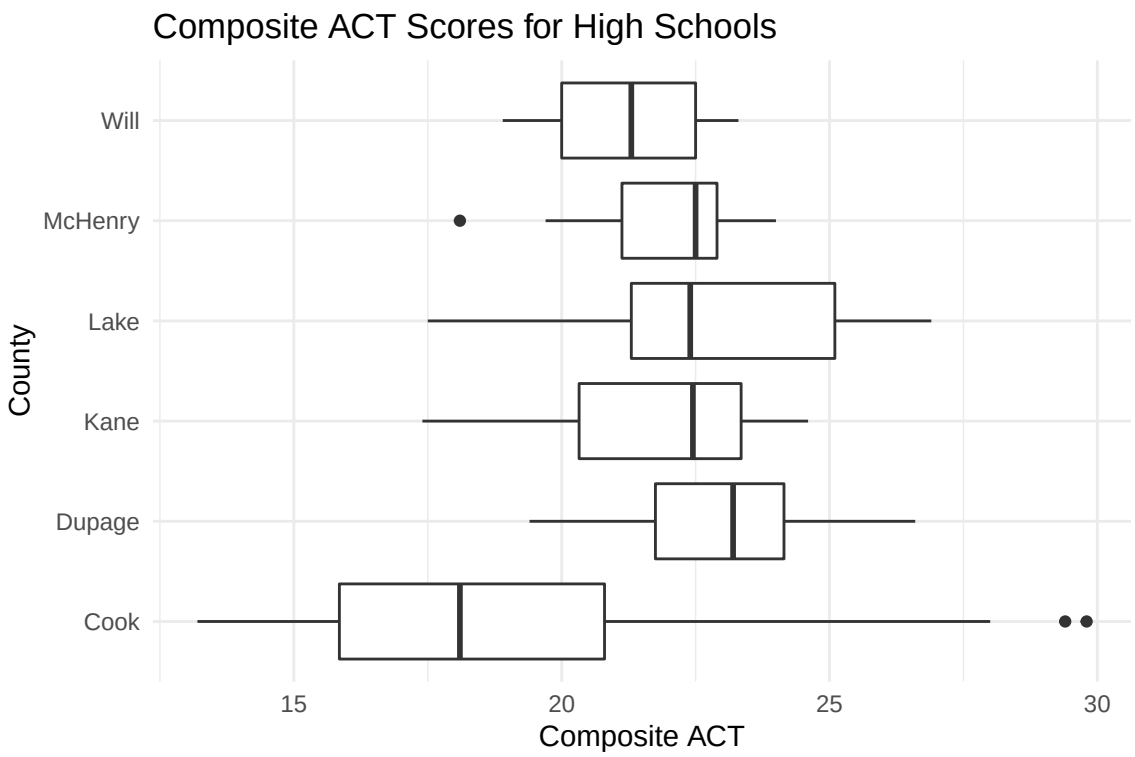
```
district_type <- rc17 %>%
  filter(COUNTY == "Lake" | COUNTY == "Dupage") %>%
  group_by(COUNTY)

two_way <- with(district_type, table(DISTRICT_SIZE_NAME, COUNTY))

kable(two_way, caption = "Types of School Districts") %>%
  kable_styling(bootstrap_options = "striped", full_width = F)
```

4.3 Resistant Measures

```
## Warning: Removed 4 rows containing non-finite values (stat_boxplot).
```



4.4 Mean vs Median

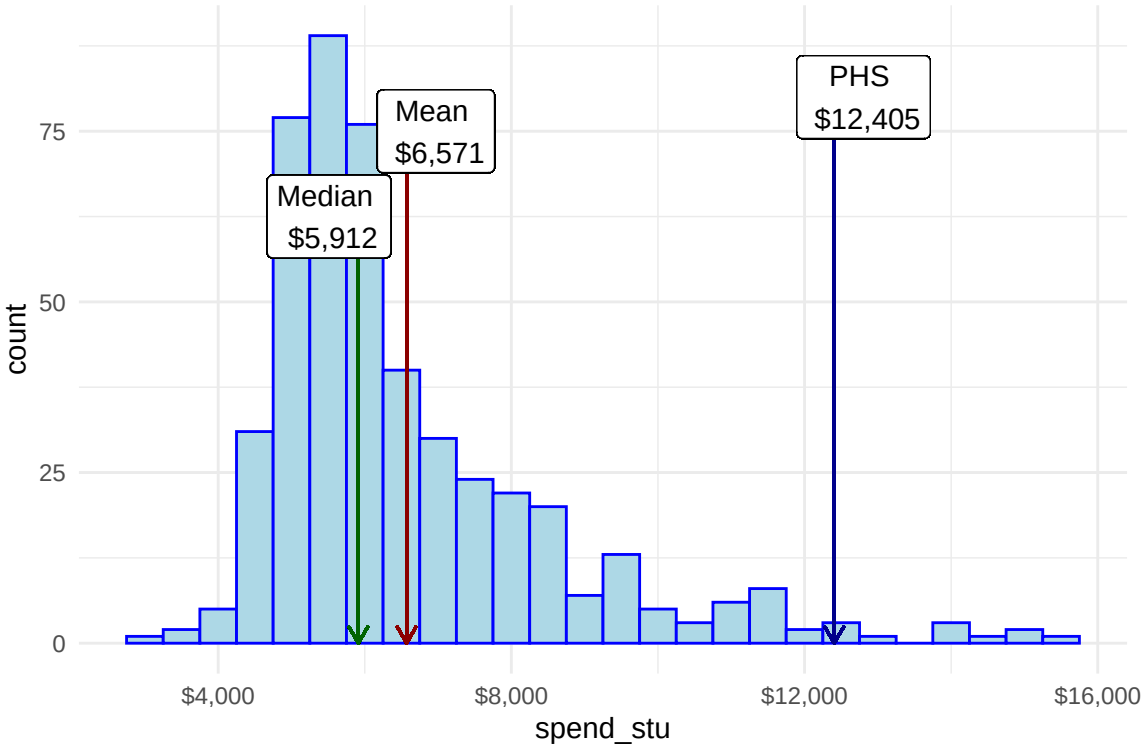
4.4.1 Instructional Spending per Pupil by District

4.4.1.1 Numeric Summary

```
rc17 %>%
  filter(SCHOOL_TYPE_NAME == "HIGH SCHOOL") %>%
  group_by(DISTRICT_NAME) %>%
  summarise(spend_stu = mean(INSTRUCT_EXPEND_PER_PUPIL_DISTRICT201516, na.rm = TRUE)) %>%
  summary()
```

```
##  DISTRICT_NAME        spend_stu
##  Length:473         Min.   : 2975
##  Class :character   1st Qu.: 5263
##  Mode  :character   Median : 5912
##                     Mean   : 6571
##                     3rd Qu.: 7315
##                     Max.   :15535
##                     NA's   :1
```

4.4.1.2 Plot



5 Correlation and Regression

5.1 Guess the Correlation

- ACT Composite vs Chronically Truant (#) Guess:_____ Actual:_____
- ACT Composite vs Chronically Truant (%) Guess:_____ Actual:_____
- ACT Composite vs Student Mobility Guess:_____ Actual:_____
- ACT Composite vs Attendance rate (%) Guess:_____ Actual:_____

5.2 Predicting ACT Scores

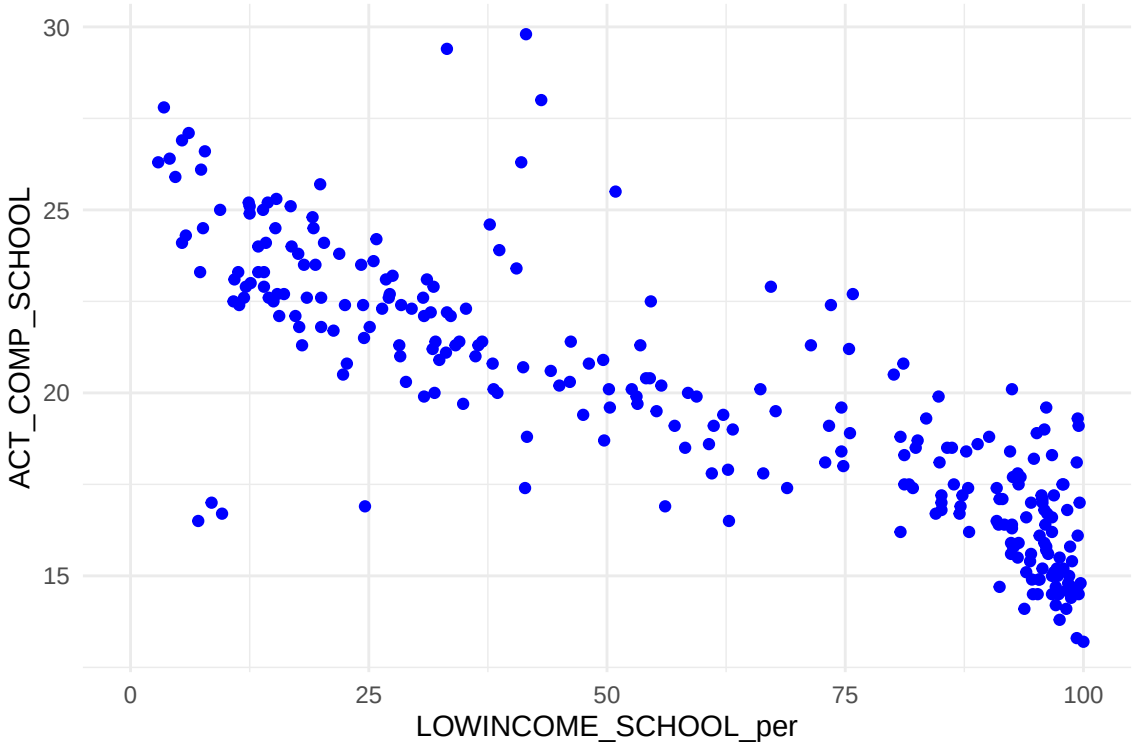
Suppose you choose 3 variables (Composite ACT Score, Enrollment and Attendance Rate) for all schools in the Six County region. What question(s) and display(s) would you explore?

5.3 Scatterplot Analysis

5.3.1 Outliers and Influential

```
ACTvLI <- sixco %>%
  ggplot(mapping = aes(x = LOWINCOME_SCHOOL_per, y = ACT_COMP_SCHOOL)) +
  geom_point(color="Blue") +
  theme_minimal()
ACTvLI
```

```
## Warning: Removed 1779 rows containing missing values (geom_point).
```

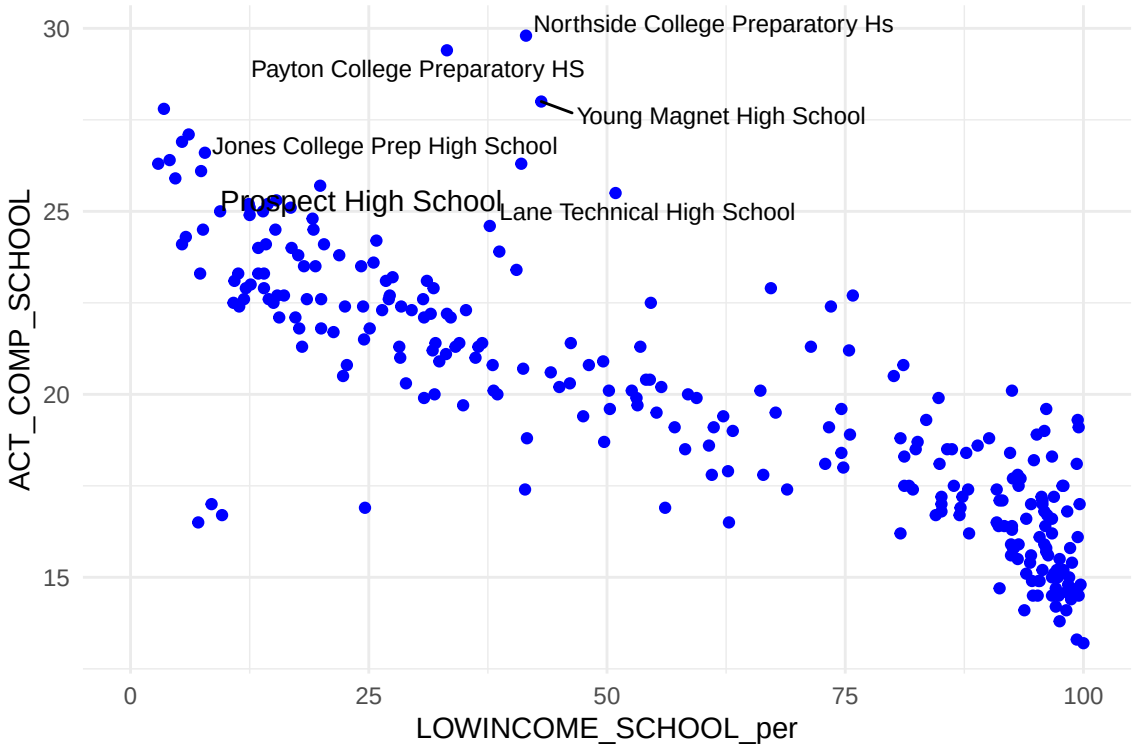


Add some labels using the `ggrepel` package. (Also notice the layering of information.)

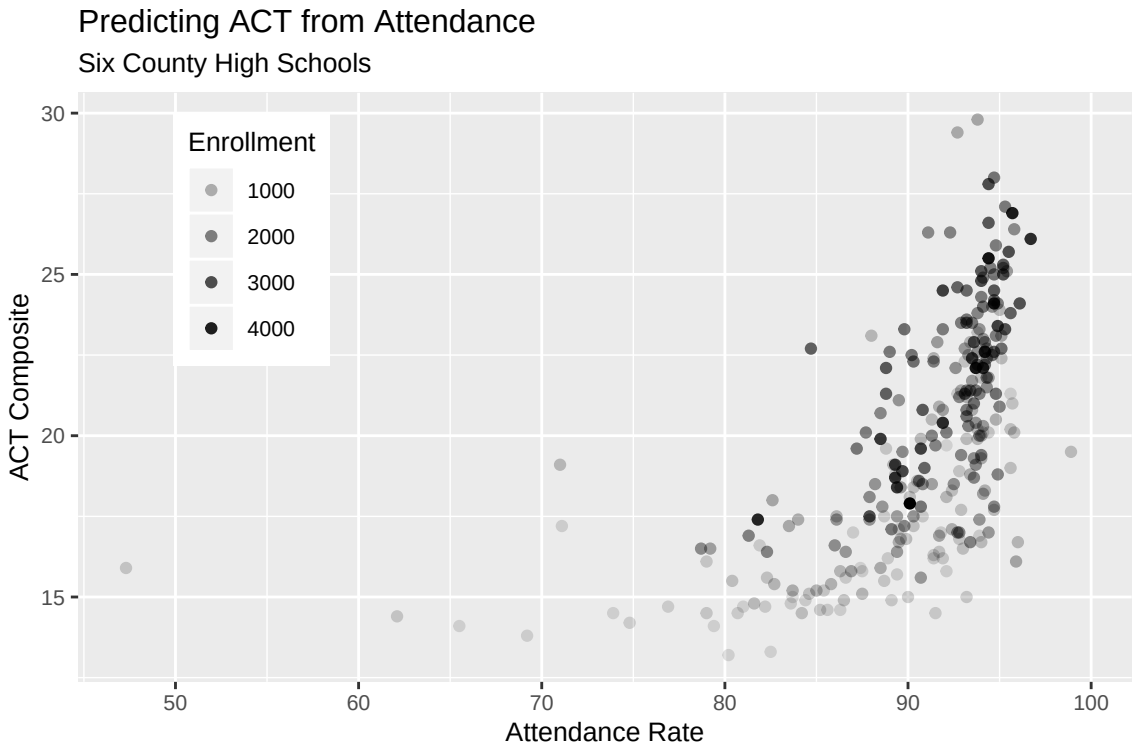
```
library(ggrepel)
```

```
ACTvLI +
  geom_text(aes(label=ifelse(SCHOOL_ID =="050162140170005",
                             as.character(SCHOOL_NAME),'')),hjust=0,vjust=0) +
  geom_text_repel(aes(LOWINCOME_SCHOOL_per, ACT_COMP_SCHOOL,
                      label = ifelse(ACT_COMP_SCHOOL >25 &
                                       LOWINCOME_SCHOOL_per>25,
                                       SCHOOL_NAME, "")), size = 3)
```

```
## Warning: Removed 1779 rows containing missing values (geom_point).
## Warning: Removed 1779 rows containing missing values (geom_text).
## Warning: Removed 1779 rows containing missing values (geom_text_repel).
```



5.3.2 Adding a Third Variable



5.3.3 Regression in Fathom

Force a variable to be numeric (option) or categorical (shift). Adding a Third Variable: Are charter schools different?

5.4 Regression Output

5.4.1 All Schools

```
summary(lm(sixco$ACT_COMP_SCHOOL~sixco$ATTENDANCE_RATE_SCHOOL_perALL))
```

```
##
## Call:
## lm(formula = sixco$ACT_COMP_SCHOOL ~ sixco$ATTENDANCE_RATE_SCHOOL_perALL)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.7088 -2.2108 -0.2343  1.8209 10.9398
##
## Coefficients:
##                                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)                        -11.26875    2.61192  -4.314 2.25e-05
## sixco$ATTENDANCE_RATE_SCHOOL_perALL   0.34311    0.02887  11.886  < 2e-16
##
## (Intercept)                        ***
## sixco$ATTENDANCE_RATE_SCHOOL_perALL ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.844 on 268 degrees of freedom
##   (1779 observations deleted due to missingness)
## Multiple R-squared:  0.3452, Adjusted R-squared:  0.3427
## F-statistic: 141.3 on 1 and 268 DF,  p-value: < 2.2e-16
```

5.4.2 Influential Removed

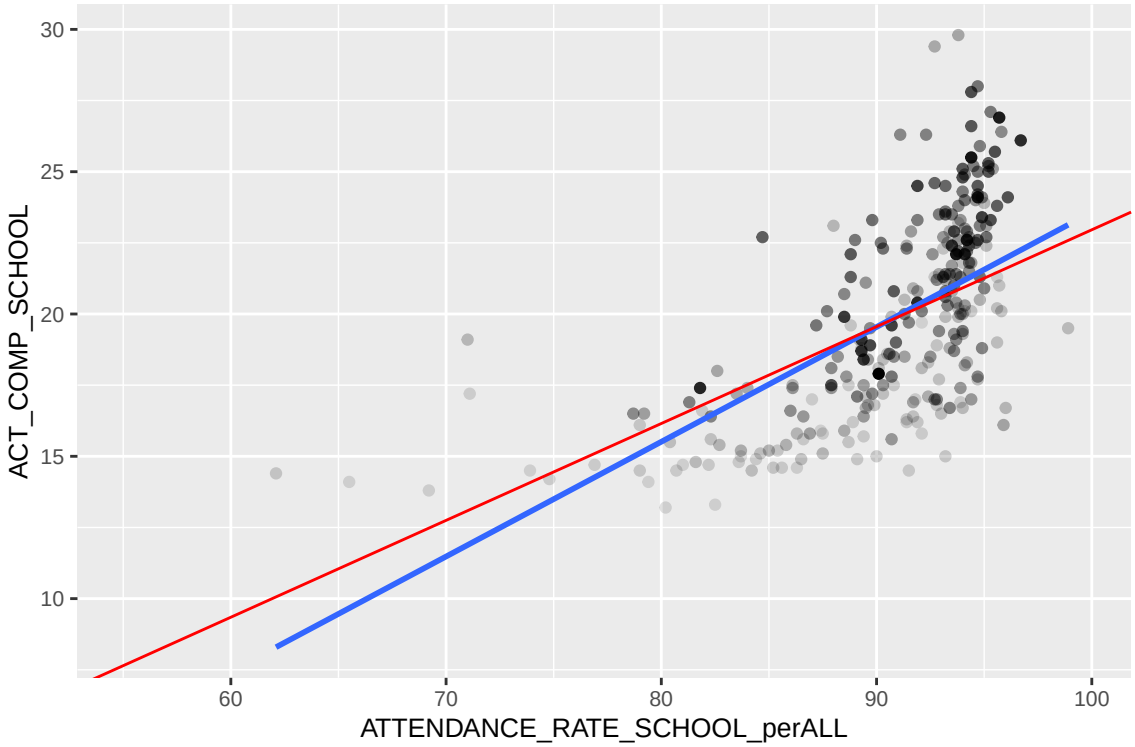
```
sixco_removed <- sixco %>%
  filter(ATTENDANCE_RATE_SCHOOL_perALL>50)

  summary(lm(sixco_removed$ACT_COMP_SCHOOL~sixco_removed$ATTENDANCE_RATE_SCHOOL_perALL))
```

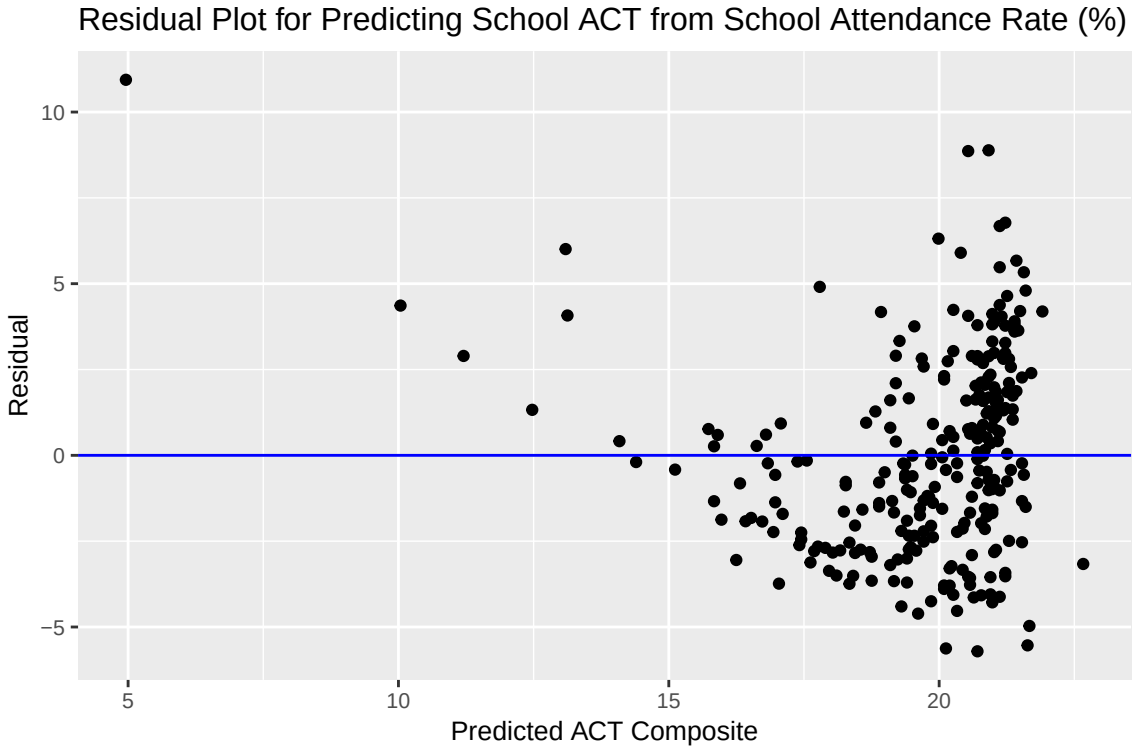
```
##
## Call:
## lm(formula = sixco_removed$ACT_COMP_SCHOOL ~ sixco_removed$ATTENDANCE_RATE_SCHOOL_perALL)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5.8340 -2.1147 -0.1728  1.6627  8.7676
##
## Coefficients:
##                                             Estimate Std. Error t value
## (Intercept)                                -16.74644    2.81182  -5.956
## sixco_removed$ATTENDANCE_RATE_SCHOOL_perALL   0.40322    0.03104  12.993
##                                            Pr(>|t|)
## (Intercept)                                8.13e-09 ***
## sixco_removed$ATTENDANCE_RATE_SCHOOL_perALL  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.75 on 267 degrees of freedom
##   (1778 observations deleted due to missingness)
```

```
## Multiple R-squared:  0.3873, Adjusted R-squared:  0.385
## F-statistic: 168.8 on 1 and 267 DF,  p-value: < 2.2e-16
```

5.4.3 Both Models



5.4.4 Residual Plot



6 Random Selection and Simulation

6.1 Rolling a die

```
set.seed(2020)
one_die <- sample(1:6, 10, replace = TRUE)
one_die
```

```
##  [1] 4 3 4 3 1 1 1 3 1 4
```

6.2 Random Selection

```
four_schools <-  sample_n(rc17, 4)
four_schools[c("SCHOOL_NAME", "SCHOOL_TOTAL_ENROLLMENT")]
```

```
## # A tibble: 4 x 2
##   SCHOOL_NAME              SCHOOL_TOTAL_ENROLLMENT
##   <chr>                                     <dbl>
## 1 McKinley Elem School                        374
## 2 Stanton School                              295
## 3 Harvard High School                         678
## 4 Hernandez Middle School                    1044
```

```
mean(four_schools$SCHOOL_TOTAL_ENROLLMENT)
```

```
## [1] 597.75
```

6.3 Stratified Sample

```
strat_samp <- sixco %>%
  filter(SCHOOL_TYPE_NAME == "HIGH SCHOOL") %>%
  group_by(COUNTY) %>%
  sample_n(3)
strat_samp[c("SCHOOL_NAME", "COUNTY", "SCHOOL_TOTAL_ENROLLMENT")]
```

```
## # A tibble: 18 x 3
## # Groups:   COUNTY [6]
##    SCHOOL_NAME                       COUNTY  SCHOOL_TOTAL_ENROLLMENT
##    <chr>                             <chr>                     <dbl>
##  1 Bogan High School                 Cook                        769
##  2 Mather High School                Cook                       1472
##  3 Ogden Int High School             Cook                        715
##  4 Westmont High School              Dupage                      449
##  5 Lake Park High School             Dupage                     2599
##  6 Glenbard South High School        Dupage                     1171
##  7 Bartlett High School              Kane                       2487
##  8 Larkin High School                Kane                       2087
##  9 Central High School               Kane                       1047
## 10 North Chicago Community High Sch  Lake                        767
## 11 Libertyville High School          Lake                       1935
## 12 Highland Park High School         Lake                       2040
## 13 Crystal Lake Central High School  McHenry                    1545
## 14 McHenry  East High School         McHenry                     795
## 15 Cary-Grove Community High School  McHenry                    1746
## 16 Peotone High School               Will                        530
```

```
## 17 Bolingbrook High School          Will                       3469
## 18 Crete-Monee High School          Will                       1634
```

6.4 Confidence Interval Simulation

INCLUDE SD IN TABLE SO CAN CALCULATE INTERVAL BY HAND

```
rand_samp <- function(samples, vari, samp_size) {
  sixco_hs_nona <- sixco_hs[!is.na(sixco_hs[vari]), ] #remove schools with no value
  a <- matrix(ncol = 6, nrow = samples)
  for (k in 1:samples){
    dat_fra <- sample_n(sixco_hs_nona, samp_size)
    t_star <- qt(.975, df = samp_size - 1)
    x_bar <- mean(dat_fra[[vari]])
    stan_dev <- sd(dat_fra[[vari]])
    lower_b <- x_bar  - t_star*stan_dev/(samp_size)**.5
    upper_b <- x_bar + t_star*stan_dev/(samp_size)**.5
  v1 <- k
  v2 <- x_bar
  v3 <- lower_b
  v4 <- upper_b
  v5 <- mean(sixco_hs[[vari]], na.rm = TRUE)
  v6 <- samp_size
  a[k,] <- c(v1, v2, v3, v4, v5, v6)}
  colnames(a) <- c("Sample", "Mean", "L_Bound", "U_Bound", "Parameter", "Sample_Size")
  return(a)
  }
```

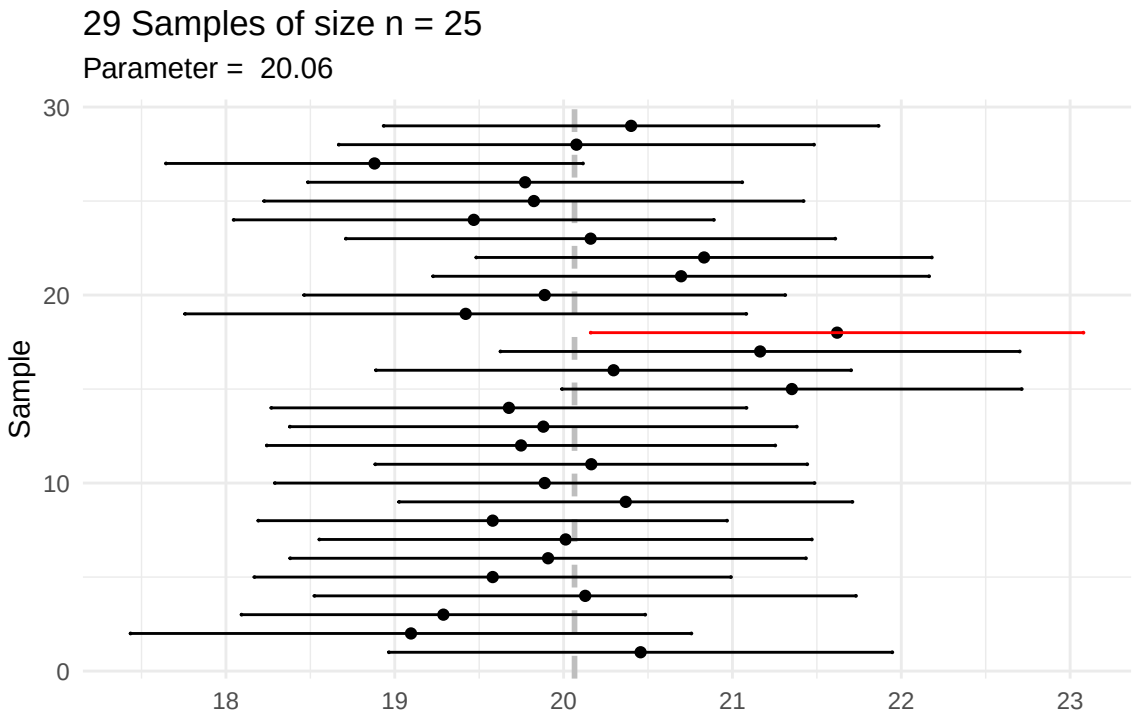
sum(dat_fra[[vari]] !=“”, na.rm = TRUE)

```
confid_ints <- as_tibble(rand_samp(29, "ACT_COMP_SCHOOL", 25))
confid_ints
```

```
## # A tibble: 29 x 6
##    Sample  Mean L_Bound U_Bound Parameter Sample_Size
##     <dbl> <dbl>   <dbl>   <dbl>     <dbl>       <dbl>
##  1      1  20.5    19.0    21.9      20.1          25
##  2      2  19.1    17.4    20.8      20.1          25
##  3      3  19.3    18.1    20.5      20.1          25
##  4      4  20.1    18.5    21.7      20.1          25
##  5      5  19.6    18.2    21.0      20.1          25
##  6      6  19.9    18.4    21.4      20.1          25
##  7      7  20.0    18.6    21.5      20.1          25
##  8      8  19.6    18.2    21.0      20.1          25
##  9      9  20.4    19.0    21.7      20.1          25
## 10     10  19.9    18.3    21.5      20.1          25
## # ... with 19 more rows
```

```
ggplot(confid_ints, mapping = aes(x=L_Bound, xend = U_Bound, y = Sample)) +
  geom_point(aes(x=Mean, y=Sample)) +
    geom_vline(xintercept = mean(confid_ints$Parameter),
               linetype="dashed",
                color = "grey",
               size=1) +
    geom_dumbbell(size_xend=0,size_x=0,
                 color = ifelse(confid_ints$U_Bound < confid_ints$Parameter |
                                confid_ints$L_Bound > confid_ints$Parameter,
                                "red", "black")) +
```

```
    labs(x = "",
         title = paste(max(confid_ints$Sample),
                       "Samples of size n =",
                       max(confid_ints$Sample_Size)
                      ),
         subtitle = paste("Parameter = ",round(confid_ints$Parameter,2))
         ) +
  theme_minimal()
```



6.5 Binomial

A basketball player claims he makes 70% of his free throws. During a recent game he made only 4 of 10. Does this cast doubt on his 70% claim or could making only 4 of 10 happen to a 70% shooter?

```
free_throws <- rbinom(300, 10, .7)
free_throws
```

```
##   [1]  6  9  8  4  9  7  6  8  7  5  6  9  8  6  5  9  7  9  9  5  9  8  8
##  [24]  6  7  6  7  7  6  7  9  7  5  6 10  4  8  8  7  7  7  9  9 10  5  7
##  [47]  6  5  7  8  7  7  9  7  5  7  8 10  8  8 10  7  8  8  7  7  4  8  7
##  [70]  7  7  7  8  7  9  5  8  8  7  9  7  7  9  6  7  9  8  7  5  7  7  7
##  [93]  7  7  7  9  7  7  7  7  9  8  8  6  6  8  9  6  5  8  7  6  8  7  7
## [116]  7  8  7  9  8  6  8  7  8  4  7  6  9  5  5  8  6  7  7  6  8  7  9
## [139]  9  5  9  8  8  8  8  6  9  8  7  7  5  7  8  8  9  7  6  8  5  7  4
## [162]  7  6  5  9  7  6  7  5  5  7  8  9  5  6  6  7  9  7  8  6  8  9  7
## [185]  7  9  7  7  9  8  9  7  8  8  7  7  6 10  6  5  5  7  9  8  8  6  9
## [208]  7  8  7  6  7  9  6  7  5  8  7  8  9  5  7  5  8  8  5 10  8  6  6
## [231]  7  9  9  7  7  8  7  8  5  7  8  4  7  5  7  7  9  5  7  7  8  5  8
## [254]  8  8  8  5 10  8  9  8  6  8 10  6  5  4  7  6  6  9  8  4  7  5  7
## [277]  8  7  7  7  7  7  7  7  6  6  9  8  7  7  8  8  9  9  7  9  6  6  6
## [300]  6
```

```
sort(free_throws)
```

```
##   [1]  4  4  4  4  4  4  4  4  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5
##  [24]  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  5  6  6  6  6  6  6
##  [47]  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6  6
##  [70]  6  6  6  6  6  6  6  6  6  6  6  6  6  7  7  7  7  7  7  7  7  7  7
##  [93]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [116]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [139]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7
## [162]  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  8  8  8  8
## [185]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [208]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8
## [231]  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  9  9  9  9  9  9
## [254]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9
## [277]  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9  9 10 10 10 10 10 10 10
## [300] 10
```

```
table(free_throws)
```

```
## free_throws
##  4  5  6  7  8  9 10
##  8 32 42 98 67 45  8
```

7 Final Thoughts

7.1 Learning More

7.1.1 R and RStudio

7.1.2 Fathom

7.1.3 Statistics

DePaul, Udacity, CodeAcademy, DataCamp