

# final project

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```
# Load necessary libraries
```

```
library(dplyr)
```

```
##
```

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

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

```
##
```

```
##      filter, lag
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      intersect, setdiff, setequal, union
```

```
library(tidyr)
```

```
library(ggplot2)
```

```
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
```

```
##   method from
```

```
##   +.gg      ggplot2
```

```
library(gridExtra)
```

```
##
```

```
## Attaching package: 'gridExtra'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##      combine
```

```
# Read the data
```

```
data <- read.csv("./Project_1_data.csv")
```

```
# 1. Descriptive statistics table for all variables
```

```
summary(data)
```

```
##      Gender      EthnicGroup      ParentEduc      LunchType
## Length:948      Length:948      Length:948      Length:948
## Class :character Class :character Class :character Class :character
## Mode  :character Mode  :character Mode  :character Mode  :character
##
```

```
##
##
##
##   TestPrep           ParentMaritalStatus PracticeSport       IsFirstChild
##   Length:948         Length:948           Length:948         Length:948
##   Class :character   Class :character     Class :character     Class :character
##   Mode  :character   Mode  :character     Mode  :character     Mode  :character
##
##
##
##   NrSiblings      TransportMeans      WklyStudyHours      MathScore
##   Min.    :0.000    Length:948        Length:948        Min.    : 0.00
##   1st Qu.:1.000    Class :character   Class :character   1st Qu.: 56.00
##   Median :2.000    Mode  :character   Mode  :character   Median : 66.00
##   Mean   :2.155                                Mean   : 65.98
##   3rd Qu.:3.000                                3rd Qu.: 76.00
##   Max.   :7.000                                Max.   :100.00
##   NA's   :46
##   ReadingScore      WritingScore
##   Min.    : 17.00    Min.    : 10.00
##   1st Qu.: 59.00    1st Qu.: 57.00
##   Median : 69.50    Median : 68.00
##   Mean   : 68.84    Mean   : 67.93
##   3rd Qu.: 80.00    3rd Qu.: 78.25
##   Max.   :100.00    Max.   :100.00
##
```

```
# 2. Explore distribution of results and consider potential transformations
```

```
# Histograms for continuous variables
```

```
hist_math <- ggplot(data, aes(x = MathScore)) + geom_histogram(bins = 30) + ggtitle("Histogram of Math Scores")
hist_reading <- ggplot(data, aes(x = ReadingScore)) + geom_histogram(bins = 30) + ggtitle("Histogram of Reading Scores")
hist_writing <- ggplot(data, aes(x = WritingScore)) + geom_histogram(bins = 30) + ggtitle("Histogram of Writing Scores")
```

```
# Boxplots for continuous variables to check for outliers
```

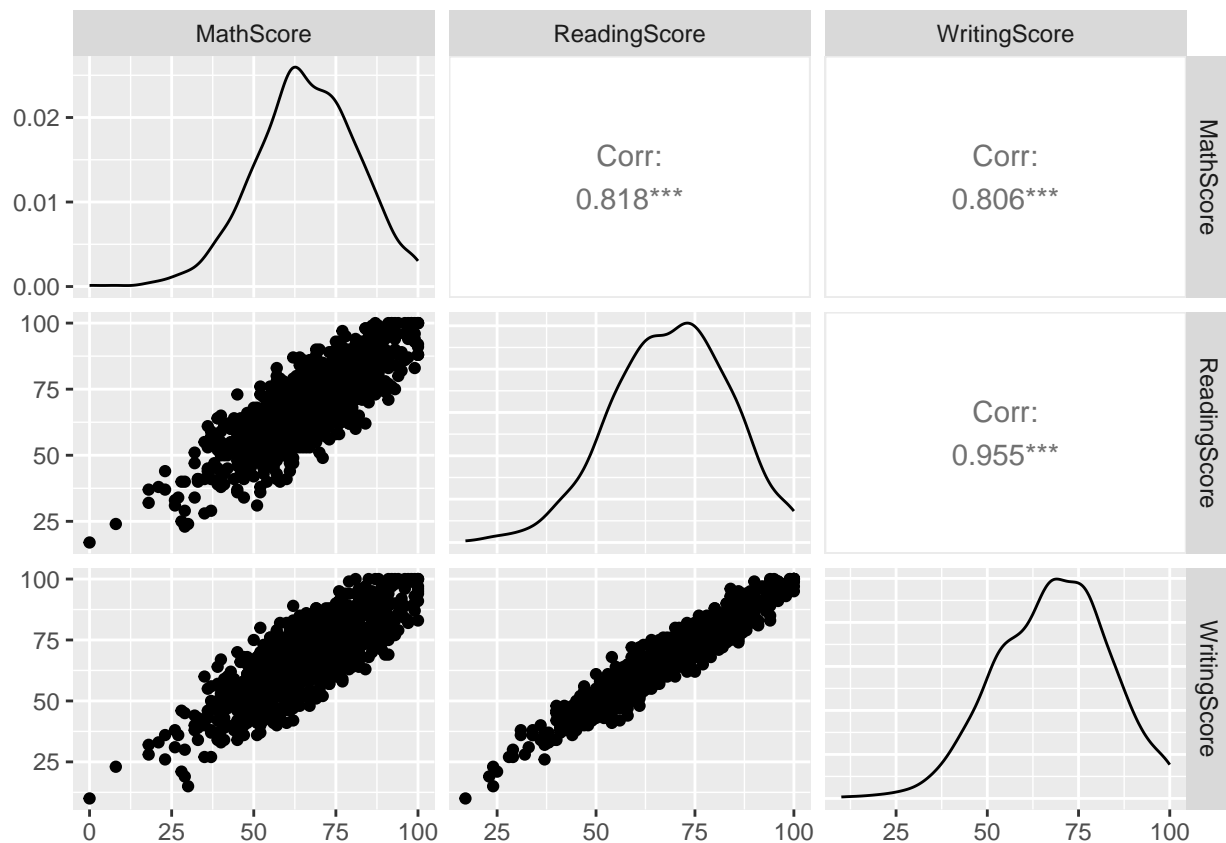
```
box_math <- ggplot(data, aes(y = MathScore)) + geom_boxplot() + ggtitle("Boxplot of Math Scores")
box_reading <- ggplot(data, aes(y = ReadingScore)) + geom_boxplot() + ggtitle("Boxplot of Reading Scores")
box_writing <- ggplot(data, aes(y = WritingScore)) + geom_boxplot() + ggtitle("Boxplot of Writing Scores")
```

```
# Grid of plots
```

```
grid.arrange(hist_math, hist_reading, hist_writing, box_math, box_reading, box_writing, ncol = 3)
```



```
# 3. Check for potential outliers or influential points
# Scatterplot matrix for continuous variables
ggpairs(data, columns = c("MathScore", "ReadingScore", "WritingScore"))
```



```
# Load necessary libraries
library(ggplot2)
library(reshape2)

##
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyr':
##
##      smiths

# Creating a function to count NA and empty strings as missing values
count_missing <- function(x) sum(is.na(x) | x == "")
# Calculating the missing values
missing_values <- sapply(data, function(x) count_missing(x))

# Creating a dataframe for missing values
missing_data_frame <- data.frame(Variable = names(missing_values), MissingValues = missing_values)

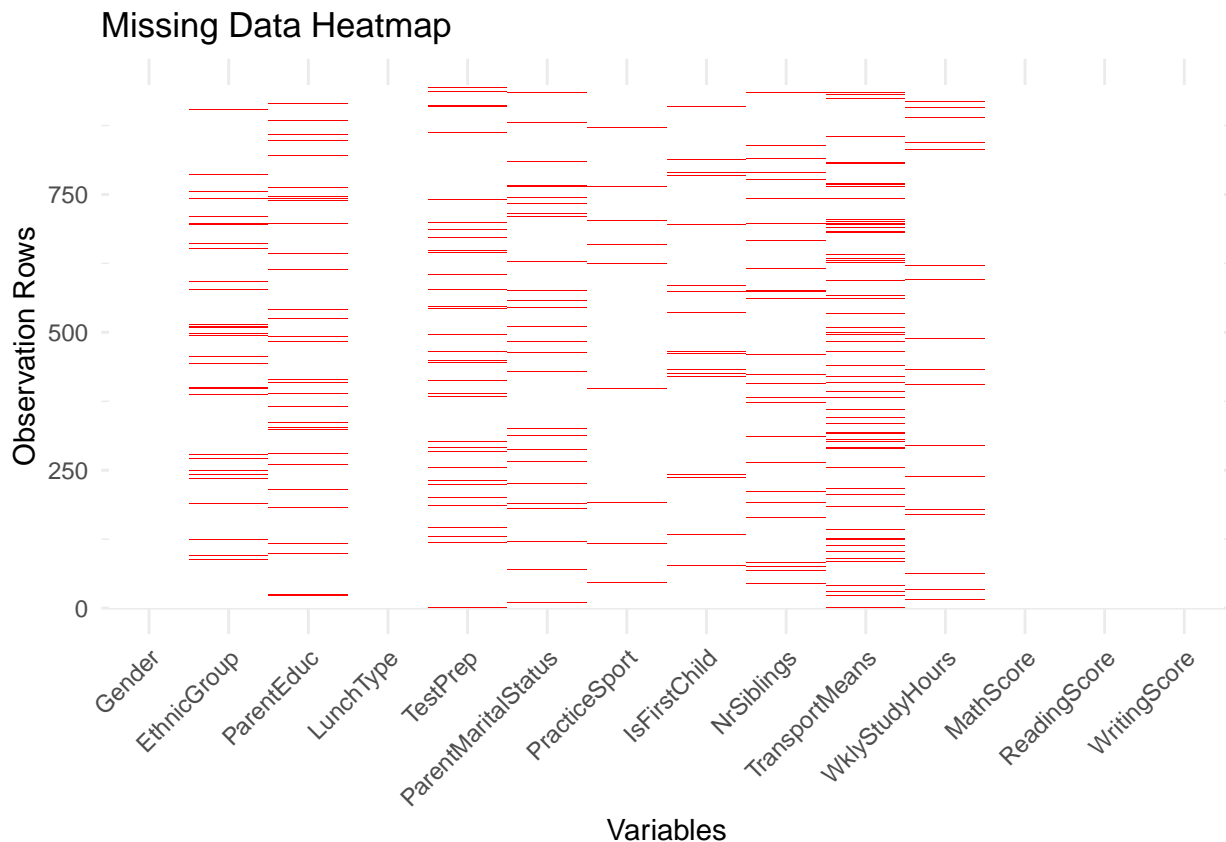
# Convert empty strings to NA
data[data == ""] <- NA

# Melt the data for visualization
melted_data <- melt(data.frame(row = 1:nrow(data), data), id.vars = 'row')

# Creating the heatmap
```

```
ggplot(melted_data, aes(x = variable, y = row)) +
  geom_tile(aes(fill = is.na(value))) +
  scale_fill_manual(values = c('white', 'red'), guide = FALSE) +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  labs(x = 'Variables', y = 'Observation Rows', title = 'Missing Data Heatmap')
```

```
## Warning: The `guide` argument in `scale_*()` cannot be `FALSE`. This was deprecated in
## ggplot2 3.3.4.
## i Please use "none" instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



```
missing_data_frame
```

##	Variable	MissingValues
## Gender	Gender	0
## EthnicGroup	EthnicGroup	59
## ParentEduc	ParentEduc	53
## LunchType	LunchType	0
## TestPrep	TestPrep	55
## ParentMaritalStatus	ParentMaritalStatus	49
## PracticeSport	PracticeSport	16
## IsFirstChild	IsFirstChild	30
## NrSiblings	NrSiblings	46
## TransportMeans	TransportMeans	102
## WklyStudyHours	WklyStudyHours	37

```
## MathScore           MathScore           0
## ReadingScore        ReadingScore         0
## WritingScore        WritingScore         0
```

```
# Imputing missing values
# For columns with fewer missing values, replace with mode
get_mode <- function(v) {
  uniqv <- unique(v)
  uniqv[which.max(tabulate(match(v, uniqv)))]
}

data$PracticeSport[is.na(data$PracticeSport)] <- get_mode(data$PracticeSport)
data$IsFirstChild[is.na(data$IsFirstChild)] <- get_mode(data$IsFirstChild)

# For columns with more missing values, you can choose to impute or drop
# Imputing with mode (as an example)
data$EthnicGroup[is.na(data$EthnicGroup)] <- get_mode(data$EthnicGroup)
data$ParentEduc[is.na(data$ParentEduc)] <- get_mode(data$ParentEduc)
data$TestPrep[is.na(data$TestPrep)] <- get_mode(data$TestPrep)
data$ParentMaritalStatus[is.na(data$ParentMaritalStatus)] <- get_mode(data$TestPrep)
data$WklyStudyHours[is.na(data$WklyStudyHours)] <- get_mode(data$WklyStudyHours)
data$NrSiblings[is.na(data$NrSiblings)] <- mean(data$NrSiblings, na.rm = TRUE)

# Alternatively, to drop rows with NA values in these columns-TransportMeans
data <- data %>% drop_na(TransportMeans)

# Creating a function to count NA and empty strings as missing values
count_missing <- function(x) sum(is.na(x) | x == "")
# Calculating the missing values
missing_values <- sapply(data, function(x) count_missing(x))

# Creating a dataframe for missing values
missing_data_frame <- data.frame(Variable = names(missing_values), MissingValues = missing_values)
missing_data_frame
```

```
##           Variable MissingValues
## Gender           Gender           0
## EthnicGroup      EthnicGroup       0
## ParentEduc       ParentEduc         0
## LunchType        LunchType          0
## TestPrep         TestPrep           0
## ParentMaritalStatus ParentMaritalStatus 0
## PracticeSport     PracticeSport       0
## IsFirstChild      IsFirstChild         0
## NrSiblings        NrSiblings           0
## TransportMeans     TransportMeans       0
## WklyStudyHours     WklyStudyHours       0
## MathScore         MathScore           0
## ReadingScore       ReadingScore         0
## WritingScore       WritingScore         0
```

## -correlation/pairwise-

```
# Load necessary libraries
library(tidyverse)

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v forcats   1.0.0      v readr     2.1.4
## v lubridate 1.9.3      v stringr  1.5.1
## v purrr     1.0.2      v tibble   3.2.1
## -- Conflicts ----- tidyverse_conflicts() --
## x gridExtra::combine() masks dplyr::combine()
## x dplyr::filter()      masks stats::filter()
## x dplyr::lag()         masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(caret)

## Loading required package: lattice
##
## Attaching package: 'caret'
##
## The following object is masked from 'package:purrr':
##
##   lift

library(car)

## Loading required package: carData
##
## Attaching package: 'car'
##
## The following object is masked from 'package:purrr':
##
##   some
##
## The following object is masked from 'package:dplyr':
##
##   recode

set.seed(123)
splitRatio <- 0.8

trainIndex <- sample(seq_len(nrow(data)), size = floor(splitRatio * nrow(data)))
trainData <- data[trainIndex, ]
testData <- data[-trainIndex, ]

# Splitting the train dataset into independent variables (X) and dependent variables (Y)
X_train <- trainData %>% select(-c(MathScore, ReadingScore, WritingScore))
Y_math_train <- trainData$MathScore
Y_reading_train <- trainData$ReadingScore
Y_writing_train <- trainData$WritingScore
```

## add interaction-

```
# Checking for interaction effects (example for math score)
full_model_math_interaction <- lm(Y_math_train ~ (.)^2, data = X_train)
full_model_reading_interaction <- lm(Y_reading_train ~ (.)^2, data = X_train)
full_model_writing_interaction <- lm(Y_writing_train ~ (.)^2, data = X_train)

# backward (compare)
AICmodel_math_interaction =
  step(full_model_math_interaction, trace = 0, direction='backward')
BICmodel_math_interaction =
  step(full_model_math_interaction, scale = log(nrow(X_train)), trace = 0, direction='backward')

#
num_params_AICmodel <- length(coef(AICmodel_math_interaction))
num_params_BICmodel <- length(coef(BICmodel_math_interaction))

cat("AIC Model Parameters:", num_params_AICmodel, "\n")

## AIC Model Parameters: 120

cat("BIC Model Parameters:", num_params_BICmodel, "\n")

## BIC Model Parameters: 246

# bic aic
model_math_interaction = AICmodel_math_interaction
model_reading_interaction =
  step(full_model_reading_interaction, trace = 0, direction='backward')
model_writing_interaction =
  step(full_model_writing_interaction, trace = 0, direction='backward')

# results
# r.squared..
glance_math = broom::glance(model_math_interaction) |>
  mutate(model = "Math") |>
  select(model, r.squared, adj.r.squared, p.value, AIC, BIC)

glance_reading = broom::glance(model_reading_interaction) |>
  mutate(model = "Reading") |>
  select(model, r.squared, adj.r.squared, p.value, AIC, BIC)

glance_writing = broom::glance(model_writing_interaction) |>
  mutate(model = "Writing") |>
  select(model, r.squared, adj.r.squared, p.value, AIC, BIC)

bind_rows(glance_math, glance_reading, glance_writing) |>
  knitr::kable()
```

model	r.squared	adj.r.squared	p.value	AIC	BIC
Math	0.4682372	0.3544247	0	5469.936	6016.395
Reading	0.2936842	0.2408230	0	5457.601	5678.894



model	r.squared	adj.r.squared	p.value	AIC	BIC
Writing	0.3865467	0.3374704	0	5409.210	5644.052

```
# coef
broom::tidy(model_math_interaction) |>
  knitr::kable(caption = "Math")
```

Table 2: Math

term	estimate	std.error	statistic	p.value
(Intercept)	46.4265795	9.7786730	4.7477382	0.0000026
Gendermale	5.8537029	3.6490090	1.6041898	0.1092401
EthnicGroupgroup B	1.2860110	5.9089243	0.2176388	0.8277904
EthnicGroupgroup C	4.9000258	5.5792741	0.8782551	0.3801847
EthnicGroupgroup D	2.9851893	5.8732628	0.5082676	0.6114673
EthnicGroupgroup E	9.9472310	6.1176194	1.6259970	0.1045169
ParentEducbachelor's degree	20.1402958	11.4104418	1.7650759	0.0780999
ParentEduchigh school	-4.1961821	9.7131075	-0.4320123	0.6658999
ParentEducmaster's degree	-16.1895448	15.6838390	-1.0322438	0.3024067
ParentEducsome college	-4.8907955	8.5747654	-0.5703708	0.5686567
ParentEducsome high school	2.6064410	9.4992133	0.2743849	0.7838907
LunchTypestandard	4.2691116	3.8404194	1.1116264	0.2667793
TestPreppone	-4.4778140	3.1256666	-1.4325949	0.1525356
ParentMaritalStatusmarried	7.1693601	6.3602514	1.1272133	0.2601385
ParentMaritalStatusnone	28.2723494	11.5510250	2.4476053	0.0146891
ParentMaritalStatussingle	21.6496875	8.0594940	2.6862341	0.0074423
ParentMaritalStatuswidowed	48.4030088	15.9956694	3.0260071	0.0025927
PracticeSportregularly	-12.4181342	7.5135852	-1.6527575	0.0989447
PracticeSportsometimes	-6.9325341	7.2335214	-0.9583899	0.3382827
IsFirstChildyes	11.0787971	6.4670856	1.7131051	0.0872507
NrSiblings	-0.5722586	0.6956723	-0.8225979	0.4110894
TransportMeansschool_bus	4.8433476	3.8907504	1.2448364	0.2137163
WklyStudyHours> 10	7.9754270	6.7822976	1.1759182	0.2401308
WklyStudyHours10-May	2.6057743	4.9612695	0.5252233	0.5996373
Gendermale:LunchTypestandard	-2.9884069	2.2376913	-1.3354867	0.1822636
Gendermale:PracticeSportregularly	3.9759187	3.7940229	1.0479427	0.2951203
Gendermale:PracticeSportsometimes	-1.5430786	3.6726664	-0.4201521	0.6745366
EthnicGroupgroup B:ParentEducbachelor's degree	6.6907045	10.4216452	0.6420008	0.5211373
EthnicGroupgroup C:ParentEducbachelor's degree	10.4105995	9.7502637	1.0677249	0.2861080
EthnicGroupgroup D:ParentEducbachelor's degree	9.0606725	10.0598803	0.9006740	0.3681516
EthnicGroupgroup E:ParentEducbachelor's degree	12.6904872	10.7797135	1.1772564	0.2395969
EthnicGroupgroup B:ParentEduchigh school	-11.4089757	7.0437891	-1.6197214	0.1058592
EthnicGroupgroup C:ParentEduchigh school	-2.8133245	6.6570205	-0.4226102	0.6727431
EthnicGroupgroup D:ParentEduchigh school	-1.0247063	7.0350927	-0.1456564	0.8842454
EthnicGroupgroup E:ParentEduchigh school	3.6514060	7.4462975	0.4903653	0.6240689
EthnicGroupgroup B:ParentEducmaster's degree	22.4345726	13.3569880	1.6796131	0.0935944
EthnicGroupgroup C:ParentEducmaster's degree	14.6187701	12.1965290	1.1986009	0.2311938
EthnicGroupgroup D:ParentEducmaster's degree	28.9636093	12.0822637	2.3972005	0.0168499
EthnicGroupgroup E:ParentEducmaster's degree	27.9130027	13.5063858	2.0666523	0.0392293
EthnicGroupgroup B:ParentEducsome college	-2.1566980	6.7974267	-0.3172815	0.7511491
EthnicGroupgroup C:ParentEducsome college	1.3246696	6.3862857	0.2074241	0.8357546
EthnicGroupgroup D:ParentEducsome college	8.6873073	6.6497917	1.3064029	0.1919557

term	estimate	std.error	statistic	p.value
EthnicGroupgroup E:ParentEducsome college	1.6386273	6.9501072	0.2357701	0.8136979
EthnicGroupgroup B:ParentEducsome high school	-9.7369760	7.3113471	-1.3317622	0.1834840
EthnicGroupgroup C:ParentEducsome high school	-4.1915646	7.2320801	-0.5795794	0.5624331
EthnicGroupgroup D:ParentEducsome high school	-2.2435213	7.1671393	-0.3130288	0.7543761
EthnicGroupgroup E:ParentEducsome high school	10.3422205	8.2440120	1.2545130	0.2101827
EthnicGroupgroup B:IsFirstChildyes	6.5578927	4.6786776	1.4016552	0.1615762
EthnicGroupgroup C:IsFirstChildyes	-2.5639926	4.4373402	-0.5778220	0.5636183
EthnicGroupgroup D:IsFirstChildyes	-1.4513301	4.4273343	-0.3278113	0.7431778
EthnicGroupgroup E:IsFirstChildyes	-3.5140522	4.9870826	-0.7046308	0.4813350
ParentEducbachelor's degree:TestPrepnone	-4.9868988	4.0695752	-1.2254101	0.2209396
ParentEduchigh school:TestPrepnone	-0.6677609	3.5700840	-0.1870435	0.8516948
ParentEducmaster's degree:TestPrepnone	-7.3194760	5.9086230	-1.2387786	0.2159502
ParentEducsome college:TestPrepnone	2.6542938	3.2412557	0.8189091	0.4131891
ParentEducsome high school:TestPrepnone	5.7562945	3.5839227	1.6061436	0.1088101
ParentEducbachelor's degree:ParentMaritalStatusmarried	-18.9971814	7.3949689	-2.5689332	0.0104609
ParentEduchigh school:ParentMaritalStatusmarried	3.2163173	4.6661447	0.6892880	0.4909296
ParentEducmaster's degree:ParentMaritalStatusmarried	-4.4775738	8.3399013	-0.5368857	0.5915613
ParentEducsome college:ParentMaritalStatusmarried	-6.4141613	4.4420222	-1.4439733	0.1493097
ParentEducsome high school:ParentMaritalStatusmarried	-5.1026381	5.2638754	-0.9693691	0.3327826
ParentEducbachelor's degree:ParentMaritalStatusnone	-19.1009567	13.6115884	-1.4032864	0.1610897
ParentEduchigh school:ParentMaritalStatusnone	-5.9565865	8.4069349	-0.7085325	0.4789116
ParentEducmaster's degree:ParentMaritalStatusnone	-4.5626913	15.5579272	-0.2932712	0.7694243
ParentEducsome college:ParentMaritalStatusnone	-9.7818367	7.5851004	-1.2896120	0.1977216
ParentEducsome high school:ParentMaritalStatusnone	-3.0041512	11.5561798	-0.2599606	0.7949904
ParentEducbachelor's degree:ParentMaritalStatussingle	-26.8113303	7.9591386	-3.3686221	0.0008078
ParentEduchigh school:ParentMaritalStatussingle	2.4288800	5.3996428	0.4498223	0.6530139
ParentEducmaster's degree:ParentMaritalStatussingle	-14.0728463	9.4798039	-1.4845082	0.1382408
ParentEducsome college:ParentMaritalStatussingle	-12.7395282	5.2138148	-2.4434179	0.0148588
ParentEducsome high school:ParentMaritalStatussingle	-6.1121271	5.9268900	-1.0312537	0.3028702
ParentEducbachelor's degree:ParentMaritalStatuswidowed	-14.3196445	16.7255463	-0.8561541	0.3922814
ParentEduchigh school:ParentMaritalStatuswidowed	-26.6173501	18.4837551	-1.4400402	0.1504188
ParentEducmaster's degree:ParentMaritalStatuswidowed	-60.8430647	28.5224639	-2.1331630	0.0333486
ParentEducsome college:ParentMaritalStatuswidowed	-12.3063663	15.9205796	-0.7729848	0.4398598
ParentEducsome high school:ParentMaritalStatuswidowed	-31.5814643	16.6303426	-1.8990267	0.0580783
ParentEducbachelor's degree:PracticeSportregularly	2.2202092	7.7280808	0.2872912	0.7739964
ParentEduchigh school:PracticeSportregularly	-6.7622690	6.0522568	-1.1173136	0.2643428
ParentEducmaster's degree:PracticeSportregularly	-6.2202310	9.4907398	-0.6554000	0.5124813
ParentEducsome college:PracticeSportregularly	-2.3931199	5.2080592	-0.4595032	0.6460525
ParentEducsome high school:PracticeSportregularly	-6.6744178	5.9856441	-1.1150709	0.2653018
ParentEducbachelor's degree:PracticeSportsometimes	-9.4510833	7.5043438	-1.2594150	0.2084089

term	estimate	std.error	statistic	p.value
ParentEduchigh school:PracticeSportsometimes	-4.1145925	5.8705322	-0.7008892	0.4836654
ParentEducmaster's degree:PracticeSportsometimes	9.9939384	7.8987927	1.2652488	0.2063121
ParentEducsome college:PracticeSportsometimes	1.7129144	5.0288514	0.3406174	0.7335203
ParentEducsome high school:PracticeSportsometimes	-3.7801746	5.7911945	-0.6527452	0.5141903
ParentEducbachelor's degree:IsFirstChildyes	-2.6059395	4.4525101	-0.5852742	0.5586008
ParentEduchigh school:IsFirstChildyes	7.1627472	3.5594469	2.0123203	0.0446679
ParentEducmaster's degree:IsFirstChildyes	6.3918810	5.4511170	1.1725819	0.2414657
ParentEducsome college:IsFirstChildyes	7.4879590	3.2716682	2.2887282	0.0224693
ParentEducsome high school:IsFirstChildyes	0.8647764	3.7881902	0.2282822	0.8195108
LunchTypestandard:PracticeSportregularly	9.6387455	3.9088429	2.4658821	0.0139684
LunchTypestandard:PracticeSportsometimes	12.6791936	3.7534359	3.3780232	0.0007812
LunchTypestandard:TransportMeansschool_bus	-3.8920193	2.2686713	-1.7155501	0.0868015
TestPreppone:WklyStudyHours> 10	-7.3054595	3.6657140	-1.9929159	0.0467590
TestPreppone:WklyStudyHours10-May	-0.4704558	2.7706629	-0.1697990	0.8652300
ParentMaritalStatusmarried:PracticeSportregularly	8.1291124	5.2974032	1.5345467	0.1254640
ParentMaritalStatusnone:PracticeSportregularly	-6.6642436	9.1580389	-0.7276933	0.4671077
ParentMaritalStatussingle:PracticeSportregularly	-6.7694139	6.7914260	-0.9967588	0.3193152
ParentMaritalStatuswidowed:PracticeSportregularly	-9.1638531	15.2622177	-0.6004274	0.5484661
ParentMaritalStatusmarried:PracticeSportsometimes	1.2681166	4.9832346	0.2544766	0.7992215
ParentMaritalStatusnone:PracticeSportsometimes	-14.4588262	8.6129286	-1.6787352	0.0937655
ParentMaritalStatussingle:PracticeSportsometimes	-12.2948013	6.5365480	-1.8809318	0.0605035
ParentMaritalStatuswidowed:PracticeSportsometimes	-6.3471459	16.0880032	-0.3945266	0.6933435
ParentMaritalStatusmarried:IsFirstChildyes	-9.1318514	3.8855738	-2.3501938	0.0191122
ParentMaritalStatusnone:IsFirstChildyes	-16.3239197	7.7134974	-2.1162799	0.0347648
ParentMaritalStatussingle:IsFirstChildyes	-4.0808988	4.3155677	-0.9456227	0.3447518
ParentMaritalStatuswidowed:IsFirstChildyes	6.5968479	12.4303215	0.5307061	0.5958343
ParentMaritalStatusmarried:TransportMeansschool_bus	6.0891770	3.3170263	1.8357337	0.0669309
ParentMaritalStatusnone:TransportMeansschool_bus	3.7270216	6.1770139	0.6033695	0.5465090
ParentMaritalStatussingle:TransportMeansschool_bus	-0.1639027	3.7709985	-0.0434640	0.9653473
ParentMaritalStatuswidowed:TransportMeansschool_bus	23.0790145	11.3528736	-2.0328787	0.0425394
PracticeSportregularly:WklyStudyHours> 10	1.6706645	5.9919159	0.2788197	0.7804868
PracticeSportsometimes:WklyStudyHours> 10	3.4759782	5.8219878	0.5970432	0.5507216
PracticeSportregularly:WklyStudyHours10-May	10.2146335	4.4951245	2.2723806	0.0234445
PracticeSportsometimes:WklyStudyHours10-May	5.6236757	4.3292744	1.2989880	0.1944865
IsFirstChildyes:NrSiblings	1.5091573	0.8194275	1.8417216	0.0660483
IsFirstChildyes:TransportMeansschool_bus	-6.1115693	2.3688594	-2.5799629	0.0101366
IsFirstChildyes:WklyStudyHours> 10	-1.5271711	3.5698979	-0.4277913	0.6689687
IsFirstChildyes:WklyStudyHours10-May	-8.0475554	2.7705677	-2.9046593	0.0038227

```

broom::tidy(model_reading_interaction) |>
  knitr::kable(caption = "Reading")

```

Table 3: Reading

term	estimate	std.error	statistic	p.value
(Intercept)	65.7798758	6.7175424	9.7922532	0.0000000
Gendermale	-11.6080261	1.8490509	-6.2778295	0.0000000
EthnicGroupgroup B	1.0790585	2.2037511	0.4896463	0.6245552
EthnicGroupgroup C	1.7834422	2.0597818	0.8658404	0.3869083
EthnicGroupgroup D	4.4127005	2.1160652	2.0853330	0.0374423
EthnicGroupgroup E	5.9118075	2.3381337	2.5284301	0.0117013

term	estimate	std.error	statistic	p.value
ParentEducbachelor's degree	0.9136485	1.9511902	0.4682519	0.6397670
ParentEduchigh school	-5.7817940	1.6377034	-3.5304281	0.0004452
ParentEducmaster's degree	3.2827913	2.4146587	1.3595260	0.1744679
ParentEducsome college	-3.2453228	1.5259567	-2.1267463	0.0338304
ParentEducsome high school	-6.1169190	1.7489333	-3.4975142	0.0005028
LunchTypestandard	5.8012434	3.7805445	1.5344994	0.1254104
TestPrepnone	-6.3218120	2.4423499	-2.5884138	0.0098651
ParentMaritalStatusmarried	11.7034130	5.3737737	2.1778761	0.0297866
ParentMaritalStatusnone	22.7082969	9.6787824	2.3461935	0.0192762
ParentMaritalStatussingle	16.7716615	6.2725112	2.6738352	0.0076940
ParentMaritalStatuswidowed	17.6825363	9.6858802	1.8255993	0.0683854
PracticeSportregularly	-8.3024089	6.2347784	-1.3316285	0.1834654
PracticeSportsometimes	-3.2194628	5.9022866	-0.5454603	0.5856307
IsFirstChildyes	10.4972547	3.7334058	2.8117101	0.0050817
NrSiblings	-0.5129290	0.9188769	-0.5582130	0.5768979
TransportMeansschool_bus	-0.0172072	1.8909454	-0.0090998	0.9927424
WklyStudyHours> 10	-4.7383908	5.5219262	-0.8581047	0.3911620
WklyStudyHours10-May	-8.5256327	4.1202349	-2.0692104	0.0389349
Gendermale:IsFirstChildyes	4.4238149	2.2554294	1.9614069	0.0502730
LunchTypestandard:PracticeSportregularly	2.9486497	3.7356731	0.7893222	0.4302216
LunchTypestandard:PracticeSportsometimes	6.9686552	3.6058218	1.9326122	0.0537333
LunchTypestandard:IsFirstChildyes	-4.8608653	2.3957172	-2.0289813	0.0428815
TestPrepnone:NrSiblings	-1.1986310	0.7526475	-1.5925530	0.1117637
TestPrepnone:TransportMeansschool_bus	3.2824899	2.3060679	1.4234142	0.1551127
ParentMaritalStatusmarried:PracticeSportregularly	3.3287072	5.1471320	0.6467111	0.5180552
ParentMaritalStatusnone:PracticeSportregularly	-11.9281924	8.4104610	-1.4182567	0.1566119
ParentMaritalStatussingle:PracticeSportregularly	-10.3748479	6.2370688	-1.6634173	0.0967279
ParentMaritalStatuswidowed:PracticeSportregularly	-11.4363255	10.7934140	-1.0595652	0.2897498
ParentMaritalStatusmarried:PracticeSportsometimes	-2.6482456	4.8449682	-0.5465971	0.5848497
ParentMaritalStatusnone:PracticeSportsometimes	-12.9946232	7.9450626	-1.6355596	0.1024329
ParentMaritalStatussingle:PracticeSportsometimes	-12.3206655	5.9661601	-2.0650913	0.0393242
ParentMaritalStatuswidowed:PracticeSportsometimes	-5.8063204	10.9703090	-0.5292759	0.5968011
ParentMaritalStatusmarried:IsFirstChildyes	-9.5414084	3.7221161	-2.5634365	0.0105959
ParentMaritalStatusnone:IsFirstChildyes	-13.7246176	7.2743462	-1.8867149	0.0596597
ParentMaritalStatussingle:IsFirstChildyes	-5.0309192	4.1179813	-1.2216955	0.2222812
ParentMaritalStatuswidowed:IsFirstChildyes	-5.3564589	7.9624567	-0.6727143	0.5013765
PracticeSportregularly:WklyStudyHours> 10	3.8386770	5.7349878	0.6693435	0.5035224
PracticeSportsometimes:WklyStudyHours> 10	3.3323734	5.5727717	0.5979741	0.5500728
PracticeSportregularly:WklyStudyHours10-May	11.1557684	4.2915422	2.5994778	0.0095560
PracticeSportsometimes:WklyStudyHours10-May	5.2803946	4.1221105	1.2809930	0.2006690
NrSiblings:WklyStudyHours> 10	1.6637810	1.1341252	1.4670170	0.1428720
NrSiblings:WklyStudyHours10-May	1.9248800	0.8720768	2.2072369	0.0276584

```

broom::tidy(model_writing_interaction) |>
  knitr::kable(caption = "Writing")

```

Table 4: Writing

term	estimate	std.error	statistic	p.value
(Intercept)	61.9265482	6.6971893	9.2466474	0.0000000
Gendermale	-9.9826535	1.0240341	-9.7483609	0.0000000

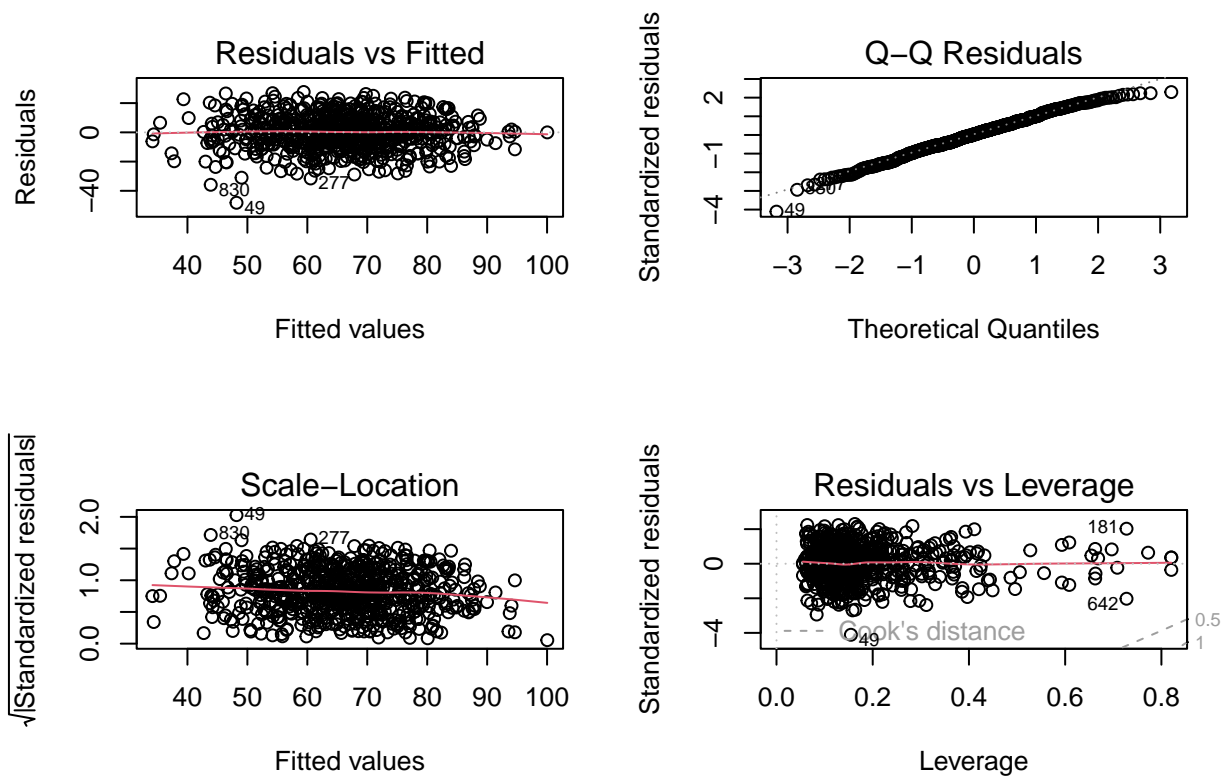
term	estimate	std.error	statistic	p.value
EthnicGroupgroup B	0.0654514	2.1192057	0.0308849	0.9753712
EthnicGroupgroup C	1.4626170	1.9857856	0.7365433	0.4616765
EthnicGroupgroup D	5.8167756	2.0348396	2.8585918	0.0043971
EthnicGroupgroup E	4.5676537	2.2604766	2.0206596	0.0437410
ParentEducbachelor's degree	4.0112810	3.3843673	1.1852381	0.2363738
ParentEduchigh school	-11.3121831	2.7729892	-4.0794184	0.0000510
ParentEducmaster's degree	4.5661449	4.0483160	1.1279122	0.2597898
ParentEducsome college	-8.6715650	2.4572171	-3.5290187	0.0004477
ParentEducsome high school	-8.9757133	2.7982907	-3.2075700	0.0014070
LunchTypestandard	4.4069028	3.6226298	1.2164927	0.2242565
TestPreppone	-6.9090852	1.9355204	-3.5696266	0.0003849
ParentMaritalStatusmarried	10.9142213	5.1958784	2.1005536	0.0360802
ParentMaritalStatusnone	16.1102104	9.3555178	1.7220009	0.0855641
ParentMaritalStatussingle	13.9428516	6.0524904	2.3036553	0.0215692
ParentMaritalStatuswidowed	17.3833233	9.2911615	1.8709527	0.0618187
PracticeSportregularly	-8.0050610	6.0475830	-1.3236794	0.1860935
PracticeSportsometimes	-3.5448887	5.7175068	-0.6200060	0.5354798
IsFirstChildyes	10.3966572	4.3950982	2.3655119	0.0183095
NrSiblings	1.1735785	0.5850748	2.0058606	0.0453016
TransportMeansschool_bus	2.2085182	1.0328734	2.1382273	0.0328854
WklyStudyHours> 10	-1.0791216	5.5829026	-0.1932904	0.8467943
WklyStudyHours10-May	-0.6963697	4.1730578	-0.1668728	0.8675241
ParentEducbachelor's degree:IsFirstChildyes	-2.7294834	4.0736856	-0.6700280	0.5030874
ParentEduchigh school:IsFirstChildyes	6.1211024	3.3659265	1.8185491	0.0694587
ParentEducmaster's degree:IsFirstChildyes	1.3621121	4.8831353	0.2789421	0.7803815
ParentEducsome college:IsFirstChildyes	8.4905041	3.0529704	2.7810633	0.0055814
ParentEducsome high school:IsFirstChildyes	3.0515243	3.4651641	0.8806291	0.3788571
LunchTypestandard:PracticeSportregularly	4.9745692	3.6115653	1.3773998	0.1688817
LunchTypestandard:PracticeSportsometimes	7.6110765	3.4766847	2.1891765	0.0289531
LunchTypestandard:IsFirstChildyes	-3.3125286	2.2960382	-1.4427149	0.1496017
TestPreppone:NrSiblings	-1.2353709	0.7223519	-1.7102064	0.0877240
ParentMaritalStatusmarried:PracticeSportregularly	4.2880870	4.9470434	0.8667979	0.3863854
ParentMaritalStatusnone:PracticeSportregularly	-11.6876890	8.1196676	-1.4394295	0.1505295
ParentMaritalStatussingle:PracticeSportregularly	-6.8144835	6.0368968	-1.1288057	0.2594129
ParentMaritalStatuswidowed:PracticeSportregularly	-16.0652176	10.3188672	-1.5568780	0.1200056
ParentMaritalStatusmarried:PracticeSportsometimes	-1.4528598	4.6731820	-0.3108931	0.7559856
ParentMaritalStatusnone:PracticeSportsometimes	-10.3841987	7.6521915	-1.3570229	0.1752638
ParentMaritalStatussingle:PracticeSportsometimes	-9.2668211	5.7609803	-1.6085493	0.1082199
ParentMaritalStatuswidowed:PracticeSportsometimes	-10.2729863	10.5613040	-0.9727006	0.3310784
ParentMaritalStatusmarried:IsFirstChildyes	-9.0482446	3.6164605	-2.5019614	0.0126052
ParentMaritalStatusnone:IsFirstChildyes	-7.8540980	7.0280393	-1.1175376	0.2641939
ParentMaritalStatussingle:IsFirstChildyes	-4.8685882	4.0051762	-1.2155740	0.2246062
ParentMaritalStatuswidowed:IsFirstChildyes	-1.2825442	7.6726284	-0.1671584	0.8672995
PracticeSportregularly:WklyStudyHours> 10	3.6112221	5.5469996	0.6510226	0.5152712
PracticeSportsometimes:WklyStudyHours> 10	4.2528427	5.4172598	0.7850542	0.4327193
PracticeSportregularly:WklyStudyHours10-May	11.1442369	4.1642242	2.6761856	0.0076418
PracticeSportsometimes:WklyStudyHours10-May	5.5753454	3.9893648	1.3975521	0.1627435
IsFirstChildyes:WklyStudyHours> 10	-0.8956186	3.3599110	-0.2665602	0.7898957
IsFirstChildyes:WklyStudyHours10-May	-5.2238123	2.5807653	-2.0241331	0.0433813

```
par(mfrow=c(2,2))
plot(model_math_interaction)
```

```
## Warning: not plotting observations with leverage one:
## 557
```

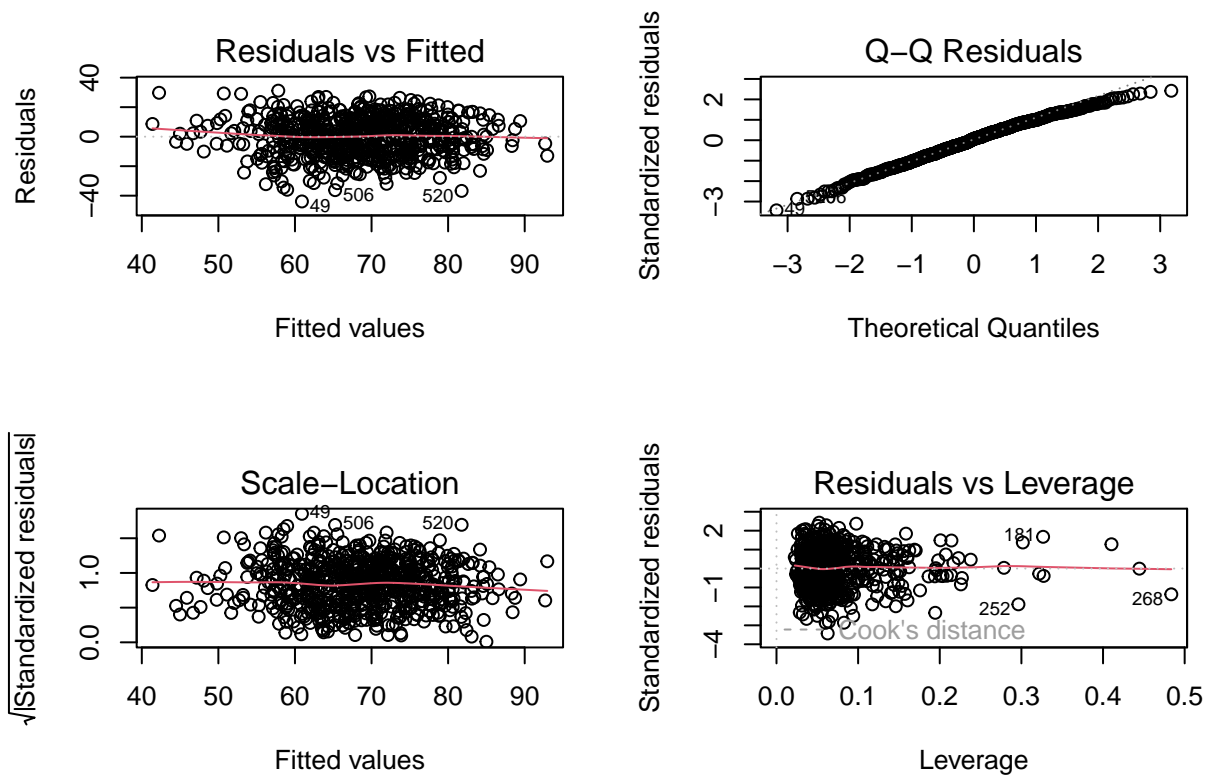
```
mtext("Math Model Diagnostic", outer = TRUE, cex = 1, line = -1)
```

### Math Model Diagnostic



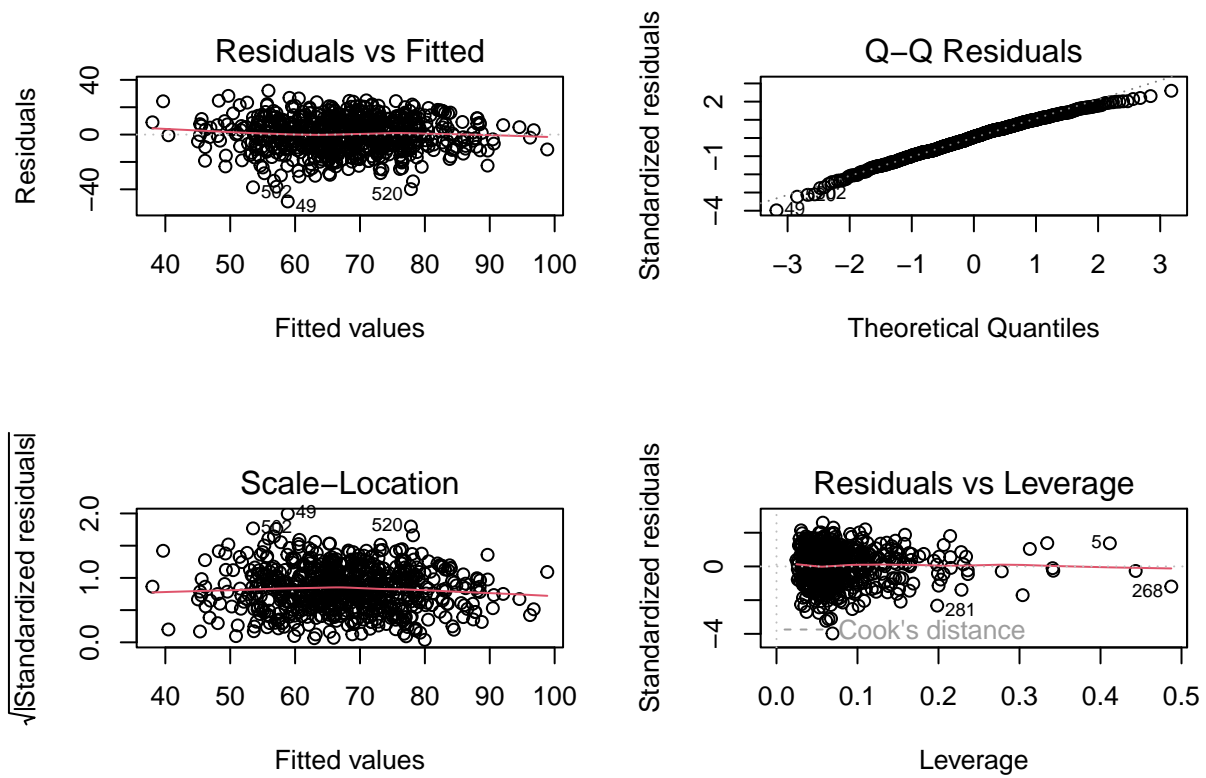
```
plot(model_reading_interaction)
mtext("Reading Model Diagnostic", outer = TRUE, cex = 1, line = -1)
```

## Reading Model Diagnostic



```
plot(model_writing_interaction)
mtext("Writing Model Diagnostic", outer = TRUE, cex = 1, line = -1)
```

## Writing Model Diagnostic



selected model

##