Lab 3 - Moderation

Structural Equation Modeling ED 216F - Instructor: Karen Nylund-Gibson

Adam Garber

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Contents

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1 Lab preparation

1.1 Creating a version-controlled R-Project with Github

Download repository here: https://github.com/garberadamc/SEM-Lab3

On the Github repository webpage:

a. `fork` your own `branch` of the lab repository
b. copy the repository web URL address from the `clone or download` menu

Within R-Studio:

c. click "NEW PROJECT" (upper right corner of window)
d. choose option `Version Control`

e. choose option `Git`
f. paste the repository web URL path copied from the `clone or download` menu on Github page
g. choose location of the R-Project (too many nested folders will result in filepath error)

1.2 Data source for example 1:

The first example utilizes the *Vocabulary and Education* dataset from the National Opinion Research Center General Social Survey. GSS Cumulative Datafile 1972-2016 (Fox, 2008) See documentation here

This dataset is available via the R-package {`carData`} and can be directly loaded into the R environment.

Note: All models specified in the following exercise are for demonstration only and are **not** theoretically justified or valid.

```
# equatiomatic is not yet on CRAN. Install the development version from GitHub with
remotes::install_github("datalorax/equatiomatic", force = TRUE)
```

```
library(tidyverse)
library(MplusAutomation)
library(rhdf5)
library(here)
library(gt)
library(gtsummary)
library(estimatr)
library(kableExtra)
library(hrbrthemes)
library(equatiomatic)
library(effects)
library(carData)
library(Ecdat)
library(huxtable)
library(flair)
```

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2 Begin lab 2 exercise

Read the dataframe into your R-environment from package {`carData`}

```
data(Vocab)

vocab <- as.data.frame(Vocab)
```

Take a look at focal variables, make a `tribble` table

Name	Labels
year	Year of the survey
sex	Sex of the respondent (Female or Male)
education	Education, in years
vocabulary	Vocabulary test score: number correct on a 10-word test

---

check some basic descriptives with the {`gtsummary`} package

```
table1 <- tbl_summary(vocab,
                      statistic = list(all_continuous() ~ "{mean} ({sd})"),
                      missing = "no" ) %>%
  bold_labels()

table1
```

Characteristic	**N = 30351**[1]
year	1995 (13)
sex	
Female	17148 (56%)
Male	13203 (44%)
education	13.0 (3.0)
vocabulary	6.00 (2.12)

[1]Statistics presented: mean (SD); n (%)

Run a regression of the model with interaction of `sex` and `education` using the `lm` function

m1_interact <- lm(formula = vocabulary ~ sex + education + sex:education ,   data=vocab)

Print summary of regression output using package {`huxtable`}

```
huxreg(m1_interact, error_pos = 'right')
```

	(1)	
(Intercept)	1.788 ***	(0.064)
sexMale	-0.277 **	(0.094)
education	0.329 ***	(0.005)
sexMale:education	0.008	(0.007)
N	30351	
R2	0.231	
logLik	-61825.557	
AIC	123661.113	

*** p < 0.001; ** p < 0.01; * p < 0.05.

Print the Latex syntax for the regression equation using the package {`equatiomatic`}

```r
extract_eq(m1_interact)
```

$$\text{vocabulary} = \alpha + \beta_{1}(\text{sex}_{\text{Male}}) + \beta_{2}(\text{education}) + \beta_{3}(\text{sex}_{\text{Male}} \times \text{education}) + \epsilon$$

```r
extract_eq(m1_interact, use_coefs = TRUE)
```

$$\text{vocabulary} = 1.79 - 0.28(\text{sex}_{\text{Male}}) + 0.33(\text{education}) + 0.01(\text{sex}_{\text{Male}} \times \text{education}) + \epsilon$$

Plot the interaction effect using the package {`effects`}

```r
int <- effect("sex:education",m1_interact)

plot(int, main="", grid=TRUE,
x.var = "education", xlab="Education",
ylab="Vocabulary", multiline=TRUE, confint=list(style="auto"))
```

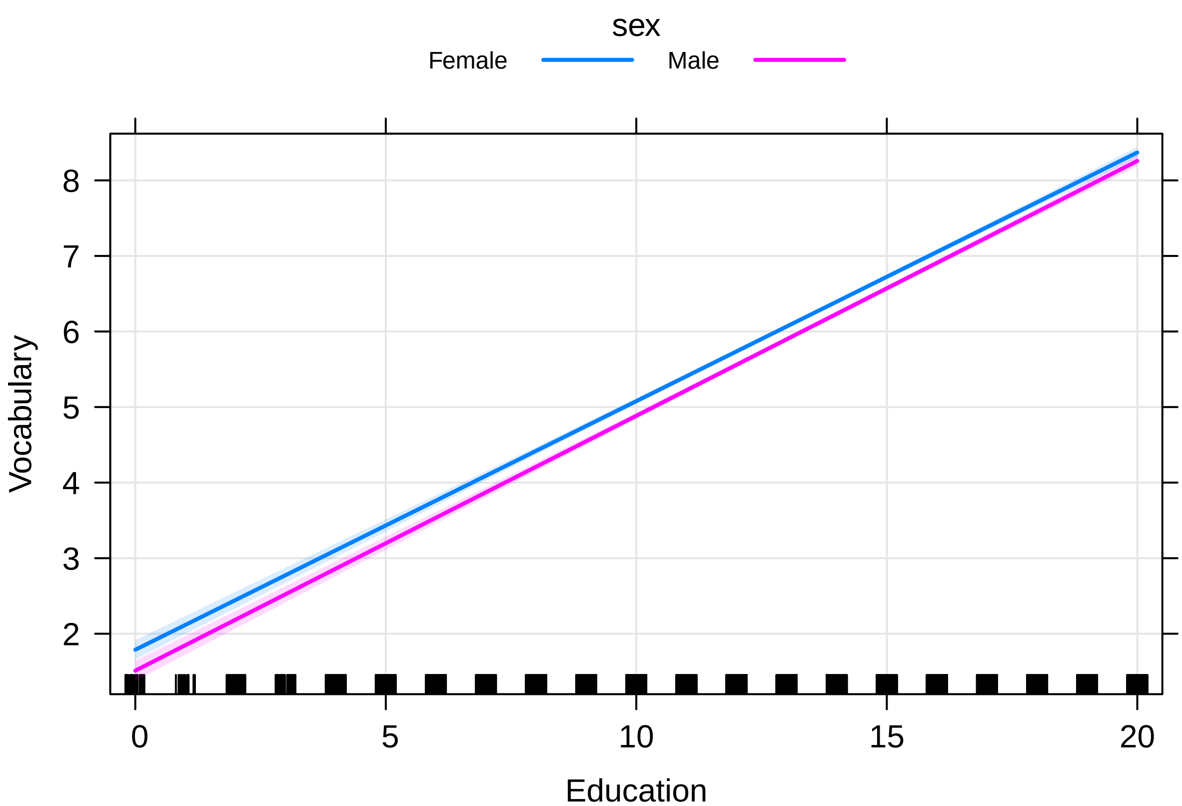


Figure. Example 1 interaction is non-significant (no moderation)

Filter year to include 1974 and 2016 (emphasizing moderation effect)

```r
vocab2 <-  vocab %>%
  filter(year %in% c(1974, 2016)) %>%
  mutate(year = droplevels(factor(year)))
```

Run regression with interaction between `year` and `education`

```r
# below is R-code to center covariate 'education'
# vocab2 <- vocab %>%
#   mutate(education = scale(education, scale = FALSE)) %>%
#   mutate(year = scale(year, scale = FALSE))

m2_interact <- lm(formula =
                           vocabulary ~ sex +
                                  education +
                                       year +
                             year:education ,
                  data=vocab2)

huxreg(m2_interact, error_pos = 'right')
```

	(1)	
(Intercept)	1.600 ***	(0.184)
sexMale	-0.073	(0.062)
education	0.375 ***	(0.015)
year2016	0.373	(0.272)
education:year2016	-0.078 ***	(0.021)
N	3307	
R2	0.244	
logLik	-6607.022	
AIC	13226.043	

*** p < 0.001; ** p < 0.01; * p < 0.05.

Print the Latex syntax for the regression equation using the package {`equatiomatic`}

```r
extract_eq(m2_interact)
```

$$\text{vocabulary} = \alpha + \beta_{1}(\text{sex}_{\text{Male}}) + \beta_{2}(\text{education}) + \beta_{3}(\text{year}_{\text{2016}}) + \beta_{4}(\text{education} \times \text{year}_{\text{2016}}) + \epsilon$$

```r
extract_eq(m2_interact, use_coefs = TRUE)
```

$$\text{vocabulary} = 1.6 - 0.07(\text{sex}_{\text{Male}}) + 0.38(\text{education}) + 0.37(\text{year}_{\text{2016}}) - 0.08(\text{education} \times \text{year}_{\text{2016}}) + \epsilon$$

Plot the interaction effect using the package {`effects`}

```r
int2 <- effect("education:year", m2_interact)

plot(int2, main="", grid=TRUE,
x.var = "education", xlab="Education",
ylab="Vocabulary",
multiline=TRUE,
confint=list(style="auto"))
```

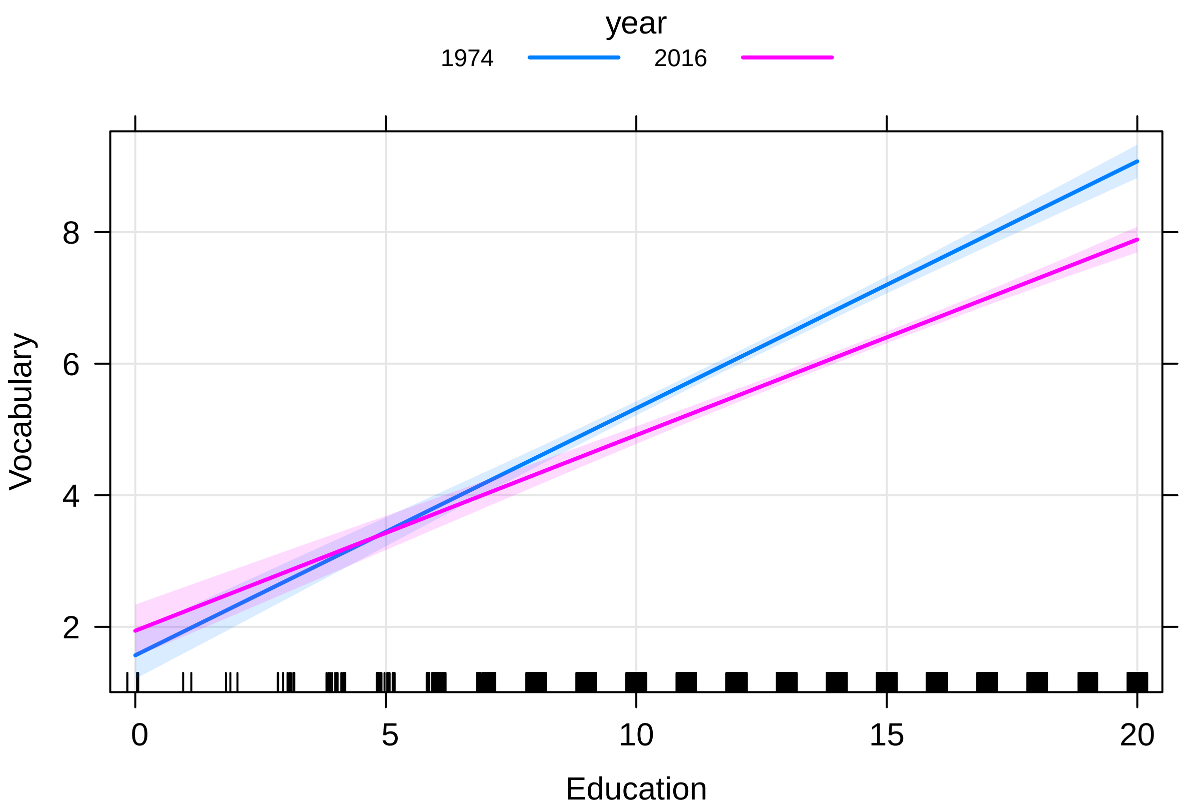
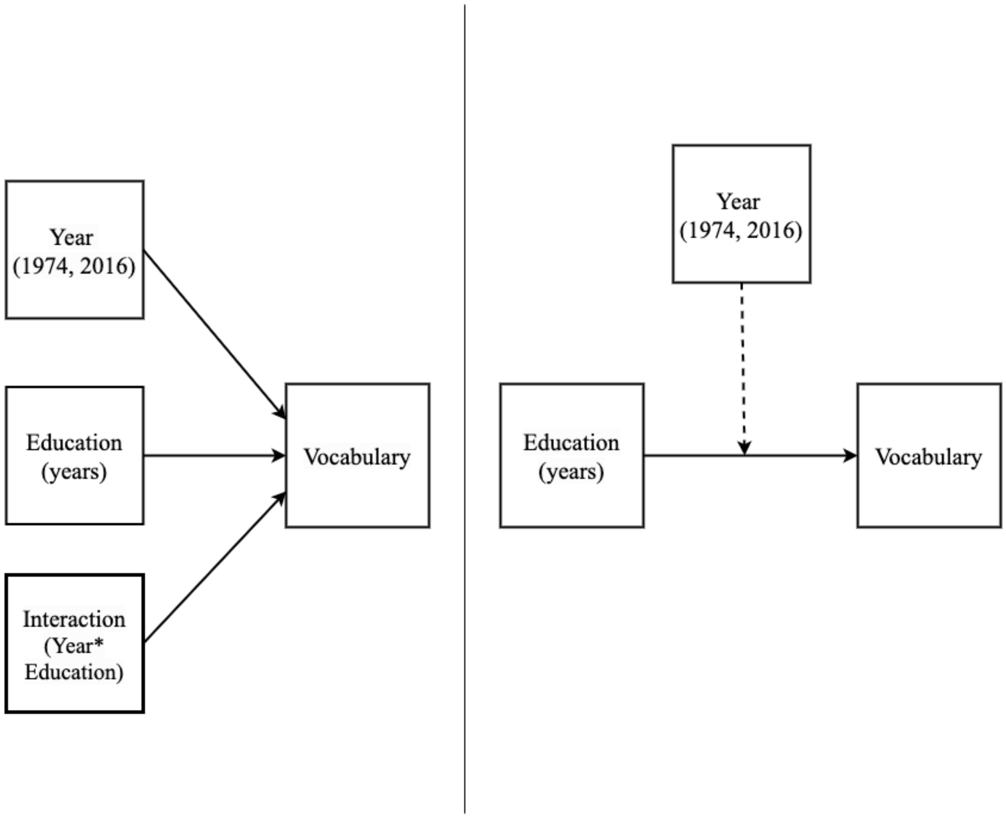


Figure. Example 2 interaction term is significant (moderation)

2.1 Estimate moderation example 1

1. covariate: Years of education (`education`)
2. moderator: Year of the survey with 2-levels 1974 and 2016 (`year`)
3. outcome: Vocabulary test score - number correct on a 10-word test (`vocabulary`)



```
education_2sd <- 2*sqrt(9.85) # 6.28

m1_model  <- mplusObject(
  TITLE = "m5 model indirect - Lab 3",
  VARIABLE =
   "usevar =
    year                ! covariate/moderator
    education           ! covariate
    vocabulary          ! outcome
    int_yred;           ! interaction of year and education",

  DEFINE =
    "center education (grandmean);
     int_yred = year*education;  ! create interaction term ",

  ANALYSIS =
    "estimator = MLR" ,

  MODEL =
   "[vocabulary](b0);
    vocabulary on
    year(b1)
    education(b2)
    int_yred(b3); " ,
```

```
  MODELCONSTRAINT =
  "LOOP(x,-1,1,0.01);
   PLOT(y1974 y2016);
   new(hi_y1974 lo_y1974 hi_y2016 lo_y2016 diff_hi);
   y1974 = b0 + b2*x;
   y2016 = b0 + b1 + (b2+b3)*x;

   hi_y1974 = b0 + b2*(6.28);
   lo_y1974 = b0 + b2*(-6.28);
   hi_y2016 = b0 + b1 + (b2 + b3)*(6.28);
   lo_y2016 = b0 + b1 + (b2 + b3)*(-6.28);
    diff_hi = hi_y2016 - hi_y1974; ",

  OUTPUT = "sampstat standardized modindices (3.84)",

  PLOT = "type=plot3;",

  usevariables = colnames(vocab2),
  rdata = vocab2)

m1_model_fit <- mplusModeler(m1_model,
                     dataout=here("mplus_files", "Lab3.dat"),
                    modelout=here("mplus_files", "model1_Lab3.inp"),
                    check=TRUE, run = TRUE, hashfilename = FALSE)
```

2.2 Create the simple slope plot from Mplus model output

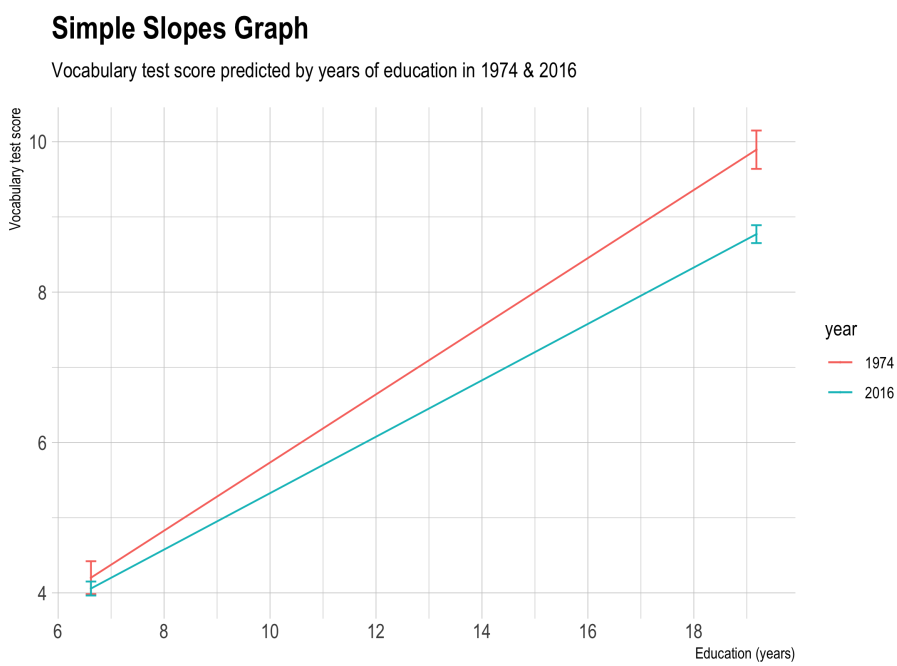
Extract the output parameters generated using the `model constraint`

```
 simp_slope <- data.frame(m1_model_fit[["results"]][["parameters"]][["unstandardized"]]) %>%
   filter(paramHeader == "New.Additional.Parameters")  %>%
   filter(param!= "DIFF_HI") %>%
   select(param, est, se) %>%
   mutate(year = case_when(
      param %in% c("HI_Y1974", "LO_Y1974") ~ "1974",
      param %in% c("HI_Y2016", "LO_Y2016") ~ "2016")) %>%
   mutate(education = case_when(
      param %in% c("HI_Y1974", "HI_Y2016") ~ 6.28,
      param %in% c("LO_Y1974", "LO_Y2016") ~ -6.28))
```

Plot the interaction effect with `ggplot` using theme from {`hrbrthemes`} package

```
# un-center 'education' so values on x-axis are on the original scale
plot_data <- simp_slope %>% mutate(education = education + 12.9)

ggplot(plot_data, aes(x=education, y=est, color=year, group=year)) +
  geom_point(size=0) +
```

```r
  geom_line() +
  geom_errorbar(aes(ymin=est-se, ymax=est+se),
                width=.2) +
  scale_x_continuous(breaks = c(seq(6,20,2))) +
  labs(title = "Simple Slopes Graph",
       subtitle = "Vocabulary test score predicted by years of education in 1974 & 2016",
           x = "Education (years)",
           y = "Vocabulary test score") +
  theme_ipsum()

ggsave(here("figures", "m1_simple_slope.png"), height = 6, width = 8)
```



2.3 Data source for example 2:

The next example utilizes the **Effects on Learning of Small Class Sizes (Star)** dataset from the *Introduction to Econometrics* textbook. (Stock et al., 2003) See documentation here

This dataset is available via the R-package {Ecdat} and can be directly loaded into the R environment.

Read the dataframe into your R-environment from package {Ecdat}

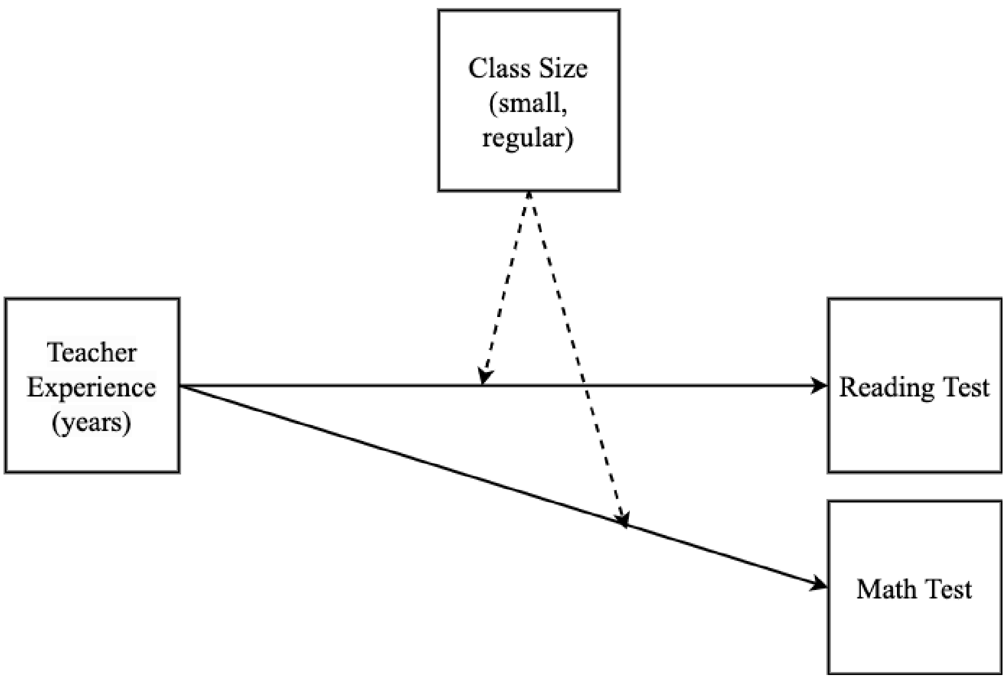
```r
data(Star)

star_data <- as.data.frame(Star)
```

Take a look at the variables in the `Star` dataset

Name	Labels
tmathssk	total math scaled score
treadssk	total reading scaled score
classk	type of class (small, regular, regular with aide)
totexpk	years of total teaching experience

Subset and recode variables to use in moderation model with `select`, `mutate`, and `case_when`

```
mod_data <- star_data %>%
  select(totexpk, # years of total teaching experience
         classk,  # type of class, a factor with levels (regular,small.class,regular.with.aide)
         tmathssk, treadssk)  %>%
  mutate(classk = case_when(
         classk == "small.class" ~ "small.class",
         classk %in% c("regular.with.aide", "regular") ~ "regular")) %>%
  mutate(classk = fct_rev(classk))
```



2.4 Estimate moderation example 2

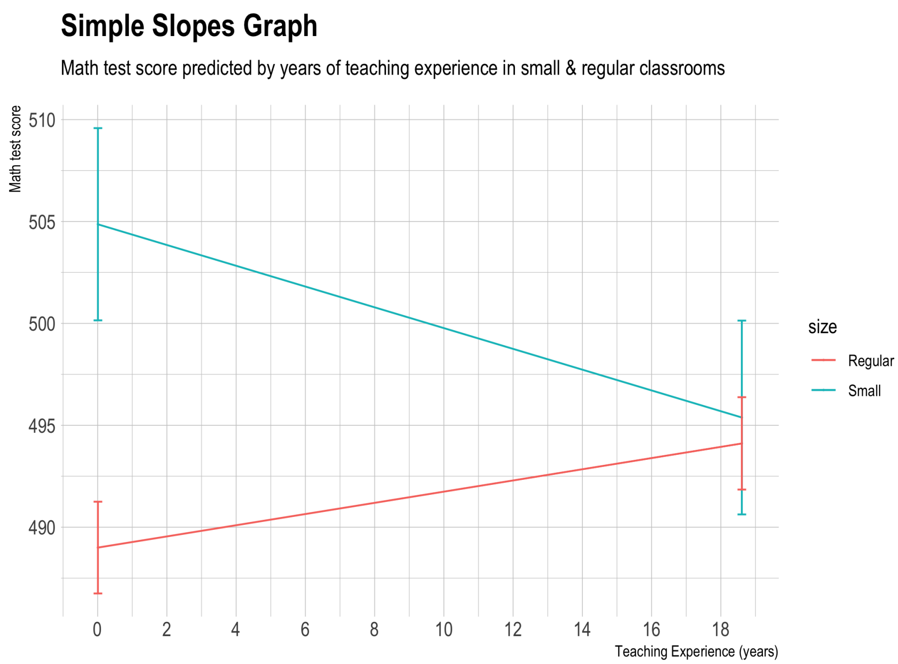
1. covariate: Years of education (`totexpk`)
2. moderator: type of class (small, regular) (`classk`)
3. outcome 1: total math scaled score (`tmathssk`)
4. outcome 2: total reading scaled score (`treadssk`)

```r
teach_exp_2sd <- sqrt(33.261) # 5.77

m2_model  <- mplusObject(
  TITLE = "m2 model indirect - Lab 3",
  VARIABLE =
   "usevar =
    totexpk classk
    tmathssk, treadssk
    tchXclas;   ",

  DEFINE =
    "center totexpk (grandmean);
     tchXclas = totexpk*classk;  ! create interaction term" ,

  ANALYSIS =
    "estimator = mlr; ",

  MODEL =
   "treadssk on classk totexpk tchXclas;

    [tmathssk](b0);

    tmathssk on
    classk (b1)
    totexpk (b2)
    tchXclas (b3); ",

  MODELCONSTRAINT =
  "LOOP(x,-1,1,0.01);
   PLOT(small regular);
   new(hi_small lo_small hi_regular lo_regular diff_hi);
     small = b0 + b2*x;
   regular = b0 + b1 + (b2+b3)*x;

     hi_small = b0 + b2*(9.3);
     lo_small = b0 + b2*(-9.3);
   hi_regular = b0 + b1 + (b2 + b3)*(9.3);
   lo_regular = b0 + b1 + (b2 + b3)*(-9.3);
      diff_hi = hi_small - hi_regular; ",

  OUTPUT = "sampstat standardized modindices (3.84)",

  PLOT = "type=plot3;",

  usevariables = colnames(mod_data),
  rdata = mod_data)

m2_model_fit <- mplusModeler(m2_model,
                     dataout=here("mplus_files", "Lab3_caschools.dat"),
                    modelout=here("mplus_files", "model2_Lab2.inp"),
                    check=TRUE, run = TRUE, hashfilename = FALSE)
```

2.5 Create the simple slope plot from Mplus model output

```
 simp_slope2 <- data.frame(m2_model_fit[["results"]][["parameters"]][["unstandardized"]]) %>%
   filter(paramHeader == "New.Additional.Parameters")  %>%
   filter(param!= "DIFF_HI") %>%
   select(param, est, se) %>%
   mutate(size = case_when(
      param %in% c("HI_SMALL", "LO_SMALL") ~ "Small",
      param %in% c("HI_REGUL", "LO_REGUL") ~ "Regular")) %>%
   mutate(experience = case_when(
      param %in% c("HI_SMALL", "HI_REGUL") ~ 9.3,
      param %in% c("LO_SMALL", "LO_REGUL") ~ -9.3))
```

```
# un-center 'experience' so values on x-axis are on the original scale
mean_exp <- mean(mod_data$totexpk)
plot_data2 <- simp_slope2 %>% mutate(experience = experience + mean_exp)

ggplot(plot_data2, aes(x=experience, y=est, color=size, group=size)) +
  geom_point(size=0) +
  geom_line() +
  geom_errorbar(aes(ymin=est-se, ymax=est+se), width=.25) +
  scale_x_continuous( breaks = c(seq(0,18,2))) +
  labs(title = "Simple Slopes Graph",
       subtitle = "Math test score predicted by years of teaching experience in small & regular classro
           x = "Teaching Experience (years)",
           y = "Math test score") +
  theme_ipsum()

ggsave(here("figures", "m2_simple_slope.png"), height = 6, width = 8)
```


Simple Slopes Graph
Math test score predicted by years of teaching experience in small & regular classrooms
Math test score
510
505
500
495
490
0
2
4
6
8
10
12
14
16
18
Teaching Experience (years)
size
Regular
Small