SAGE

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1 Intro

1.1 Import Libraries

```
library(tidyverse)
library(tidymodels)
library(ggpubr)
library(sjPlot)
theme_set(theme_pubr())

#for statistics
library(car)
library(lme4)
library(lmerTest)

# for EFA
library(psych) #Main FA work
library(corrplot)
library(nFactors) #Help with number of factors to extract
library(FactoMineR) #Additional functions
library(GPArotation)
library(parameters)
library(lavaan) #For CFA

getS3method("print","loadings") #get the hidden method and modify it
```

```
## function (x, digits = 3L, cutoff = 0.1, sort = FALSE, ...)
## {
##     Lambda <- unclass(x)
##     p <- nrow(Lambda)
##     factors <- ncol(Lambda)
##     if (sort) {
##         mx <- max.col(abs(Lambda))
##         ind <- cbind(1L:p, mx)
##         mx[abs(Lambda[ind]) < 0.5] <- factors + 1
##         Lambda <- Lambda[order(mx, 1L:p), ]
##     }
##     cat("\nLoadings:\n")
##     fx <- setNames(format(round(Lambda, digits)), NULL)
##     nc <- nchar(fx[1L], type = "c")
##     fx[abs(Lambda) < cutoff] <- strrep(" ", nc)
##     print(fx, quote = FALSE, ...)
```

```
##     vx <- colSums(x^2)
##     varex <- rbind(`SS loadings` = vx)
##     if (is.null(attr(x, "covariance"))) {
##         varex <- rbind(varex, `Proportion Var` = vx/p)
##         if (factors > 1)
##             varex <- rbind(varex, `Cumulative Var` = cumsum(vx/p))
##     }
##     cat("\n")
##     print(round(varex, digits))
##     invisible(x)
## }
## <bytecode: 0x0000023d1cd1bf60>
## <environment: namespace:stats>
```

```
printLoadings <- function (x, digits = 3, cutoff = 0.1, sort = FALSE, ...)
{
   Lambda <- unclass(x)
   p <- nrow(Lambda)
   factors <- ncol(Lambda)
   if (sort) {
      mx <- max.col(abs(Lambda))
      ind <- cbind(1L:p, mx)
      mx[abs(Lambda[ind]) < 0.5] <- factors + 1
      Lambda <- Lambda[order(mx, 1L:p), ]
   }
   cat("\nLoadings:\n")
   fx <- format(round(Lambda, digits))
   names(fx) <- NULL
   nc <- nchar(fx[1L], type = "c")
   fx[abs(Lambda) < cutoff] <- paste(rep(" ", nc), collapse = "")
   newx <- print(fx, quote = FALSE, ...) # I assigned this to a variable
   vx <- colSums(x^2)
   varex <- rbind(`SS loadings` = vx)
   if (is.null(attr(x, "covariance"))) {
      varex <- rbind(varex, `Proportion Var` = vx/p)
      if (factors > 1)
         varex <- rbind(varex, `Cumulative Var` = cumsum(vx/p))
   }
   cat("\n")
   print(round(varex, digits))
   invisible(newx) #previously returned x
}
```

1.2 Summary

Import -> Tidy Data -> Transform into what we want -> Analyze

1.2.1 EFA process

1. Calculate the Kaiser-Meyer-Olkin (KMO) values for every item. If any items have a KMO below the cutoff value, then the item with the lowest value is removed and the step is repeated. KMO values above 0.6 are kept, though above 0.8 are preferred. KMO measures the suitability for factor analysis by estimating the proportion of variance among all observed variables.
2. Check whether the items can be factored using Bartlett's test of sphericity. A low p-score indicates that factor analysis can be performed. Compares the correlation matrix to the identity matrix (checks

whether there are correlations)
3. Calculate the EFA model using factoring and a specified number of factors.
4. Calculate the commonalities, which are the proportion of the item's variance explained by the factors. If any item is below the cutoff (<0.2), then the item with the lowest value is dropped and then restart at Step 1.
5. Calculate the item loadings. If there are items that fail to load to any factor, then remove the item with the smallest max loading and then restart at Step 1.
6. Create a model for the CFA by placing each item onto the factor that contains the item's largest loading. If any items load equally onto more than one factor, then add to all factors where this is the case.
7. Fit this model using Confirmatory Factor Analysis to the original data and extract a fit statistic (Akaike information criterion, or similar) to be used as a comparison for the ideal number of factors.
8. Change the number of factors and repeat the above steps.
9. Plot the fit statistic vs the number of factors. The model with the local minimum index is the preferred model.

2 Data Prep

2.1 Import Data

```
raw_df <- read.csv(file = "./ExportedFiles/SAGE_Raw_EFA.csv")
```

2.2 Process Data

Columns 1, 2, 54, 55 (intervention) are course information Columns 3 - 34 are the questions from SAGE Columns 35 - 53 are demographics questions

```
dat <- raw_df[,3:34]
set.seed(42)
df_split <- initial_split(raw_df, prop = 0.5)
train_data <- training(df_split)
test_data <- testing(df_split)
```

2.3 Reduce the demographic questions

Gender -> Man, Woman, Other, Prefer not to disclose Raceethnicity -> Systemically Dominant [SD] (white, asian), Systemically Non Dominant [SND], Mixed, Prefer not to disclose Education -> 1st gen, not 1st gen, Prefer not to disclose

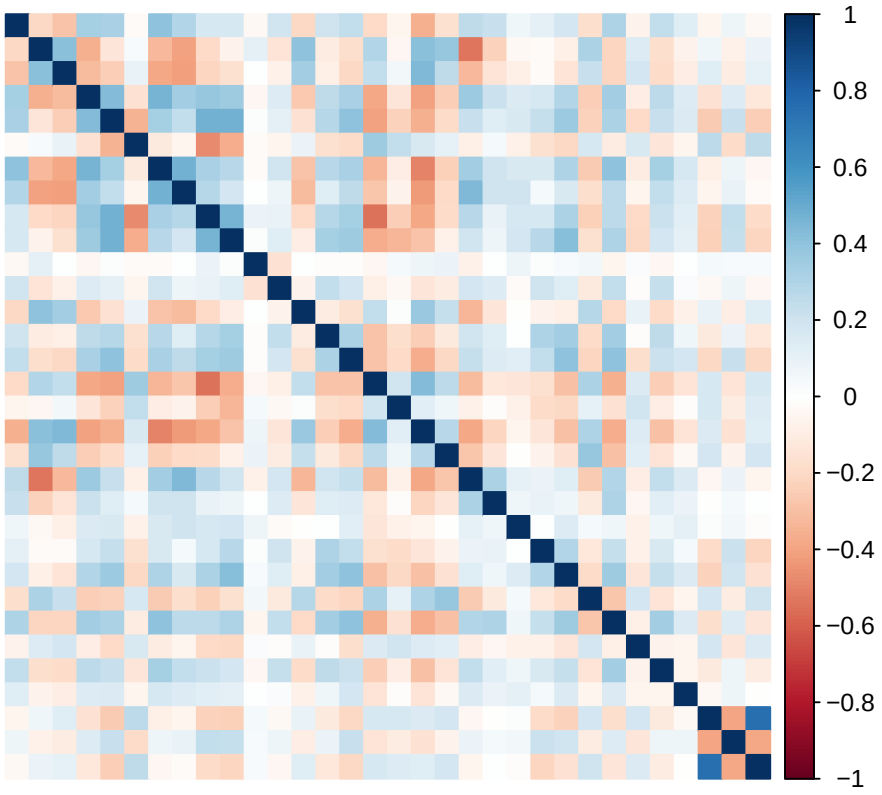
```
raw_df <- raw_df %>%
  mutate(Gender_group = case_when(Gender== 'Male' ~ 'Man',
                                  Gender == 'Female' ~ 'Woman',
                                  str_detect(Gender, 'Prefer') ~ 'Drop',
                                  TRUE ~ 'Other'))

raw_df <- raw_df %>%
  mutate(Raceethnicity_group = case_when(Raceethnicity == 'Asian' ~ 'SD',
                                         Raceethnicity == 'Asian,White' ~ 'SD',
                                         Raceethnicity == 'White' ~ 'SD',
                                         str_detect(Raceethnicity, 'Prefer') ~ 'Drop',
                                         str_detect(Raceethnicity, ',White') ~ 'Mixed',
                                         str_detect(Raceethnicity, 'Asian,') ~ 'Mixed',
                                         TRUE ~ 'SND'))

raw_df <- raw_df %>%
```

```
  mutate(Education_group = case_when(Education == 'Other' ~ '1stGen',
                                     Education== 'High school' ~ '1stGen',
                                     Education == 'Some college but no degree' ~ '1stGen',
                                     Education == "Associate's or technical degree" ~ '1stGen',
                                     str_detect(Education, 'Prefer') ~ 'Drop',
                                     TRUE ~ 'Not1stGen'))
```

3 EFA

3.1 Correlations

```
M = cor(dat)
corrplot(M, method = 'color', tl.pos='n')
```



3.2 KMO Test

- 0.00 to 0.49 unacceptable
- 0.50 to 0.59 miserable
- 0.60 to 0.69 mediocre
- 0.70 to 0.79 middling
- 0.80 to 0.89 meritorious
- 0.90 to 1.00 marvelous

```
KMO(dat)
```

```
## Kaiser-Meyer-Olkin factor adequacy
## Call: KMO(r = dat)
## Overall MSA =  0.91
```

```
## MSA for each item =
##                                                 When.I.work.in.a.group..I.do.higher.quality.work.
##                                                                                              0.93
##                                             When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
##                                                                                              0.87
##                               The.work.takes.more.time.to.complete.when.I.work.with.other.students.
##                                                                                              0.93
##                                     My.group.members.help.explain.things.that.I.do.not.understand.
##                                                                                              0.95
##                                                  When.I.work.in.a.group..I.am.able.to.share.my.ideas.
##                                                                                              0.94
##                                 My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
##                                                                                              0.88
##                               The.material.is.easier.to.understand.when.I.work.with.other.students.
##                                                                                              0.94
##                                       The.workload.is.usually.less.when.I.work.with.other.students.
##                                                                                              0.92
##                                                                 My.group.members.respect.my.opinions.
##                                                                                              0.91
##                                                    I.feel.I.am.part.of.what.is.going.on.in.the.group.
##                                                                                              0.93
##                                          I.prefer.when.one.student.regularly.takes.on.a.leadership.role.
##                                                                                              0.55
##                                             I.prefer.when.the.leadership.role.rotates.between.students.
##                                                                                              0.86
##                                                                 I.do.not.think.a.group.grade.is.fair.
##                                                                                              0.94
##                                                  I.try.to.make.sure.my.group.members.learn.the.material.
##                                                                                              0.93
##                                                  I.learn.to.work.with.students.who.are.different.from.me.
##                                                                                              0.95
##                                                       My.group.members.do.not.care.about.my.feelings.
##                                                                                              0.93
##                                                         I.let.the.other.students.do.most.of.the.work.
##                                                                                              0.89
##                                                          I.feel.working.in.groups.is.a.waste.of.time.
##                                                                                              0.95
##                                                 I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
##                                                                                              0.91
##                                               When.I.work.with.other.students.the.work.is.divided.equally.
##                                                                                              0.91
##                                             We.cannot.complete.the.assignment.unless.everyone.contributes.
##                                                                                              0.88
##                                                          I.prefer.to.take.on.tasks.that.I.m.already.good.at.
##                                                                                              0.78
##                             I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
##                                                                                              0.91
##                                                I.also.learn.when.I.teach.the.material.to.my.group.members.
##                                                                                              0.93
##                         I.become.frustrated.when.my.group.members.do.not.understand.the.material.
##                                                                                              0.93
##                                                Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
##                                                                                              0.92
##                 When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
```

```
##                                                                                0.87
##                My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.
##                                                                                0.91
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
##                                                                                0.82
##   You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
##                                                                                0.73
##                           Your.physics.intelligence.is.something.about.you.that.you.can.change.
##                                                                                0.91
##          You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##                                                                                0.71
```

```
dat <- dat[, KMO(dat)$MSAi>0.6]
```

3.3 Bartlett's Test of Sphericity

```
cortest.bartlett(dat)
```

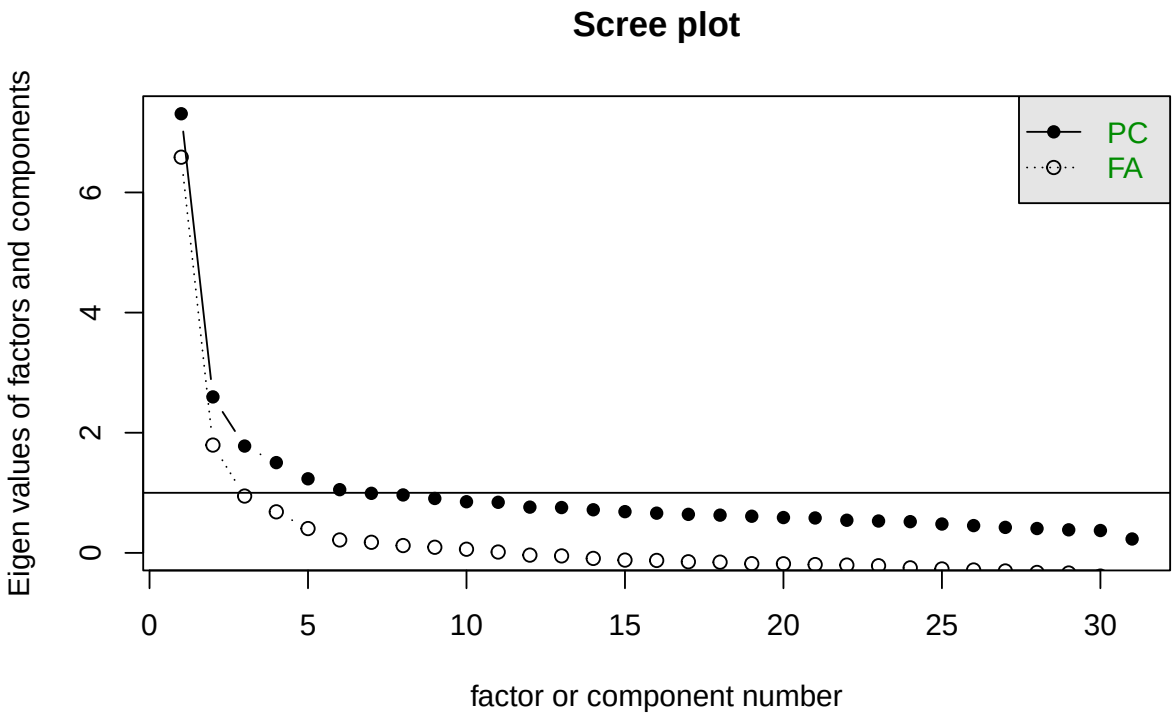
```
## $chisq
## [1] 11396.19
##
## $p.value
## [1] 0
##
## $df
## [1] 465
```

3.4 Scree Plot

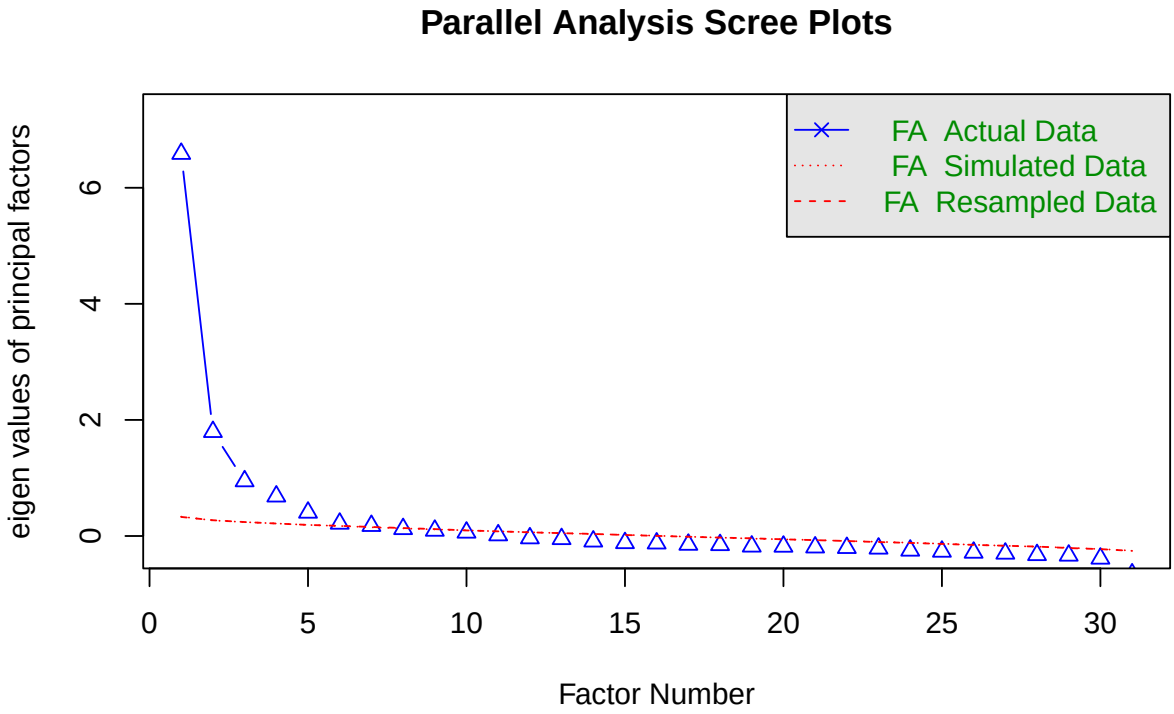
```
ev <- eigen(M)
ev$values
```

```
##  [1] 7.3116232 2.6028414 1.7870438 1.5517266 1.2405477 1.0768273 1.0348560
##  [8] 0.9694283 0.9545786 0.9031255 0.8509518 0.8297582 0.7570119 0.7333450
## [15] 0.7006816 0.6811850 0.6608574 0.6319138 0.6229019 0.6049351 0.5871973
## [22] 0.5802351 0.5415617 0.5302511 0.5190530 0.4776188 0.4498368 0.4198294
## [29] 0.4020717 0.3834987 0.3715396 0.2311666
```

```
scree(dat)
```




```
fa.parallel(dat, fa="fa")
```




```
## Parallel analysis suggests that the number of factors =  7  and the number of components =  NA
```

3.5 EFA loop

Uses the training data set

```
for (Nfacs in 3:9){
  df <- train_data[,3:34]
  loadings_test = TRUE
  while (loadings_test) {
    communs_test = TRUE
    while (communs_test){
      df <- df[, KMO(df)$MSAi>0.6]
      if (cortest.bartlett(df)$p.value > 0.05){print("Bartlett test failed")}
      df.efa <- fa(df, nfactors = Nfacs, rotate = "oblimin")
      if (min(abs(df.efa$communality))<0.2) {
        df <- df[, -c(which.min(abs(df.efa$communality)))]
      }
      else {
        communs_test = FALSE
      }
    }
    cutoff <- 0.1
    Lambda <- unclass(df.efa$loadings)
    p <- nrow(Lambda)
    fx <- setNames(Lambda, NULL)
    fx[abs(Lambda) < cutoff] <- NA_real_
    fx <- as.data.frame(fx)
    fx$max <- do.call(pmax, c(abs(fx), na.rm = TRUE))
    if (min(fx$max)<0.3) {
      df <- df[, -which.min(fx$max)]
    }
    else {
      loadings_test = FALSE
      }
  }
  str <- paste0("cfa.fit",Nfacs)
  model <- efa_to_cfa(df.efa, threshold = 0.3)
  cfa.fit <- cfa(model = model, data = test_data)
  assign(str,cfa.fit)
}
```

3.6 CFA

Now we need to compare the CFA outputs of each and determine which is the optimal model

```
anova(cfa.fit3, cfa.fit4, cfa.fit5, cfa.fit6, cfa.fit7, cfa.fit8, cfa.fit9)
```

```
##
## Chi-Squared Difference Test
##
##           Df   AIC   BIC  Chisq Chisq diff    RMSEA Df diff Pr(>Chisq)
## cfa.fit9 215 16742 17121 616.36
## cfa.fit3 224 16033 16265 821.53    205.164 0.184977       9  < 2.2e-16 ***
## cfa.fit7 228 16522 16842 651.28   -170.245 0.000000       4   1.000000
## cfa.fit6 260 17198 17487 845.15    193.867 0.089112      32  < 2.2e-16 ***
## cfa.fit5 263 17316 17592 856.75     11.596 0.067069       3   0.008903 **
## cfa.fit4 267 17358 17616 906.48     49.736 0.133977       4  4.099e-10 ***
```

```
## cfa.fit8 269 18553 18918 725.49   -180.991 0.000000       2   1.000000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

From this, 7 - 9 factors are near equivalent with n=7 to have a lower AIC and n=9 to have a lower Chisq.

```
df.efa <- fa(dat, nfactors = 7, rotate = "oblimin")

mmm <- printLoadings(df.efa$loadings, cutoff = 0.3)
```

```
##
## Loadings:
##                                                                                                  MR1
## When.I.work.in.a.group..I.do.higher.quality.work.                                                 0.47
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.                            -0.51
## My.group.members.help.explain.things.that.I.do.not.understand.                                    0.31
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
## The.material.is.easier.to.understand.when.I.work.with.other.students.                             0.64
## The.workload.is.usually.less.when.I.work.with.other.students.                                     0.53
## My.group.members.respect.my.opinions.
## I.feel.I.am.part.of.what.is.going.on.in.the.group.
## I.prefer.when.the.leadership.role.rotates.between.students.
## I.do.not.think.a.group.grade.is.fair.
## I.try.to.make.sure.my.group.members.learn.the.material.
## I.learn.to.work.with.students.who.are.different.from.me.
## My.group.members.do.not.care.about.my.feelings.
## I.let.the.other.students.do.most.of.the.work.
## I.feel.working.in.groups.is.a.waste.of.time.                                                     -0.51
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
## When.I.work.with.other.students.the.work.is.divided.equally.
## We.cannot.complete.the.assignment.unless.everyone.contributes.
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
## I.also.learn.when.I.teach.the.material.to.my.group.members.
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.                  0.33
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
## Your.physics.intelligence.is.something.about.you.that.you.can.change.
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##                                                                                                  MR4
## When.I.work.in.a.group..I.do.higher.quality.work.
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.
## My.group.members.help.explain.things.that.I.do.not.understand.
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.                                              0.37
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.                                -0.67
## The.material.is.easier.to.understand.when.I.work.with.other.students.
## The.workload.is.usually.less.when.I.work.with.other.students.
## My.group.members.respect.my.opinions.                                                             0.71
## I.feel.I.am.part.of.what.is.going.on.in.the.group.                                                0.48
```

```
## I.prefer.when.the.leadership.role.rotates.between.students.
## I.do.not.think.a.group.grade.is.fair.
## I.try.to.make.sure.my.group.members.learn.the.material.
## I.learn.to.work.with.students.who.are.different.from.me.
## My.group.members.do.not.care.about.my.feelings.                                  -0.5
## I.let.the.other.students.do.most.of.the.work.                                    -0.3
## I.feel.working.in.groups.is.a.waste.of.time.
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
## When.I.work.with.other.students.the.work.is.divided.equally.
## We.cannot.complete.the.assignment.unless.everyone.contributes.
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
## I.also.learn.when.I.teach.the.material.to.my.group.members.
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
## Your.physics.intelligence.is.something.about.you.that.you.can.change.
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##                                                                                  MR2
## When.I.work.in.a.group..I.do.higher.quality.work.
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.
## My.group.members.help.explain.things.that.I.do.not.understand.
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
## The.material.is.easier.to.understand.when.I.work.with.other.students.
## The.workload.is.usually.less.when.I.work.with.other.students.
## My.group.members.respect.my.opinions.
## I.feel.I.am.part.of.what.is.going.on.in.the.group.
## I.prefer.when.the.leadership.role.rotates.between.students.
## I.do.not.think.a.group.grade.is.fair.
## I.try.to.make.sure.my.group.members.learn.the.material.
## I.learn.to.work.with.students.who.are.different.from.me.
## My.group.members.do.not.care.about.my.feelings.
## I.let.the.other.students.do.most.of.the.work.
## I.feel.working.in.groups.is.a.waste.of.time.
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
## When.I.work.with.other.students.the.work.is.divided.equally.
## We.cannot.complete.the.assignment.unless.everyone.contributes.
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
## I.also.learn.when.I.teach.the.material.to.my.group.members.
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.    0.8
## Your.physics.intelligence.is.something.about.you.that.you.can.change.                           -0.4
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.           0.8
##                                                                                  MR6
```

```
## When.I.work.in.a.group..I.do.higher.quality.work.
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.                    -0.54
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.
## My.group.members.help.explain.things.that.I.do.not.understand.
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
## The.material.is.easier.to.understand.when.I.work.with.other.students.
## The.workload.is.usually.less.when.I.work.with.other.students.
## My.group.members.respect.my.opinions.
## I.feel.I.am.part.of.what.is.going.on.in.the.group.
## I.prefer.when.the.leadership.role.rotates.between.students.
## I.do.not.think.a.group.grade.is.fair.
## I.try.to.make.sure.my.group.members.learn.the.material.
## I.learn.to.work.with.students.who.are.different.from.me.
## My.group.members.do.not.care.about.my.feelings.
## I.let.the.other.students.do.most.of.the.work.
## I.feel.working.in.groups.is.a.waste.of.time.
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
## When.I.work.with.other.students.the.work.is.divided.equally.                 0.75
## We.cannot.complete.the.assignment.unless.everyone.contributes.               0.35
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
## I.also.learn.when.I.teach.the.material.to.my.group.members.
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
## Your.physics.intelligence.is.something.about.you.that.you.can.change.
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##                                                                              MR5
## When.I.work.in.a.group..I.do.higher.quality.work.
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.
## My.group.members.help.explain.things.that.I.do.not.understand.
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
## The.material.is.easier.to.understand.when.I.work.with.other.students.
## The.workload.is.usually.less.when.I.work.with.other.students.
## My.group.members.respect.my.opinions.
## I.feel.I.am.part.of.what.is.going.on.in.the.group.
## I.prefer.when.the.leadership.role.rotates.between.students.                  0.43
## I.do.not.think.a.group.grade.is.fair.
## I.try.to.make.sure.my.group.members.learn.the.material.                      0.47
## I.learn.to.work.with.students.who.are.different.from.me.
## My.group.members.do.not.care.about.my.feelings.
## I.let.the.other.students.do.most.of.the.work.
## I.feel.working.in.groups.is.a.waste.of.time.
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
## When.I.work.with.other.students.the.work.is.divided.equally.
## We.cannot.complete.the.assignment.unless.everyone.contributes.
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.       0.30
```

```
## I.also.learn.when.I.teach.the.material.to.my.group.members.
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.                    0.35
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.    0.41
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
## Your.physics.intelligence.is.something.about.you.that.you.can.change.
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##                                                                                MR3
## When.I.work.in.a.group..I.do.higher.quality.work.
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.
## My.group.members.help.explain.things.that.I.do.not.understand.
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
## The.material.is.easier.to.understand.when.I.work.with.other.students.
## The.workload.is.usually.less.when.I.work.with.other.students.
## My.group.members.respect.my.opinions.
## I.feel.I.am.part.of.what.is.going.on.in.the.group.
## I.prefer.when.the.leadership.role.rotates.between.students.
## I.do.not.think.a.group.grade.is.fair.
## I.try.to.make.sure.my.group.members.learn.the.material.
## I.learn.to.work.with.students.who.are.different.from.me.
## My.group.members.do.not.care.about.my.feelings.
## I.let.the.other.students.do.most.of.the.work.
## I.feel.working.in.groups.is.a.waste.of.time.
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.                       0.49
## When.I.work.with.other.students.the.work.is.divided.equally.
## We.cannot.complete.the.assignment.unless.everyone.contributes.
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
## I.also.learn.when.I.teach.the.material.to.my.group.members.
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.       0.50
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
## Your.physics.intelligence.is.something.about.you.that.you.can.change.
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##                                                                                MR7
## When.I.work.in.a.group..I.do.higher.quality.work.
## When.I.work.in.a.group..I.end.up.doing.most.of.the.work.
## The.work.takes.more.time.to.complete.when.I.work.with.other.students.
## My.group.members.help.explain.things.that.I.do.not.understand.
## When.I.work.in.a.group..I.am.able.to.share.my.ideas.
## My.group.members.make.me.feel.that.I.am.not.as.smart.as.they.are.
## The.material.is.easier.to.understand.when.I.work.with.other.students.
## The.workload.is.usually.less.when.I.work.with.other.students.
## My.group.members.respect.my.opinions.
## I.feel.I.am.part.of.what.is.going.on.in.the.group.
## I.prefer.when.the.leadership.role.rotates.between.students.
## I.do.not.think.a.group.grade.is.fair.
```

```
## I.try.to.make.sure.my.group.members.learn.the.material.
## I.learn.to.work.with.students.who.are.different.from.me.                                        0.38
## My.group.members.do.not.care.about.my.feelings.
## I.let.the.other.students.do.most.of.the.work.
## I.feel.working.in.groups.is.a.waste.of.time.
## I.have.to.work.with.students.who.are.not.as.smart.as.I.am.
## When.I.work.with.other.students.the.work.is.divided.equally.
## We.cannot.complete.the.assignment.unless.everyone.contributes.
## I.prefer.to.take.on.tasks.that.I.m.already.good.at.
## I.prefer.to.take.on.tasks.that.will.help.me.better.learn.the.material.
## I.also.learn.when.I.teach.the.material.to.my.group.members.                                     0.33
## I.become.frustrated.when.my.group.members.do.not.understand.the.material.
## Everyone.s.ideas.are.needed.if.we.are.going.to.be.successful.
## When.I.work.with.other.students..we.spend.too.much.time.talking.about.other.things.
## My.group.did.higher.quality.work.when.my.group.members.worked.on.tasks.together.
## My.group.did.higher.quality.work.when.group.members.worked.on.different.tasks.at.the.same.time.  0.30
## You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.
## Your.physics.intelligence.is.something.about.you.that.you.can.change.
## You.can.learn.new.things..but.you.can.t.really.change.your.basic.physics.intelligence.
##
##                   MR1   MR4   MR2   MR6   MR5   MR3   MR7
## SS loadings     1.944 2.010 1.800 1.284 1.121 0.939 0.881
## Proportion Var 0.063 0.065 0.058 0.041 0.036 0.030 0.028
## Cumulative Var 0.063 0.128 0.186 0.227 0.263 0.293 0.322
```

```
write.csv(as.table(mmm),"R_factors.csv")
```

3.7 Cronbach Alpha

```
f1 <- dat[, c("When.I.work.in.a.group..I.do.higher.quality.work.", "The.work.takes.more.time.to.complete
f2 <- dat[, c("You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change
f3 <- dat[, c("I.have.to.work.with.students.who.are.not.as.smart.as.I.am.", "I.become.frustrated.when.my
f4 <- dat[, c("My.group.members.respect.my.opinions.", "My.group.members.make.me.feel.that.I.am.not.as.s
f5 <- dat[, c("I.try.to.make.sure.my.group.members.learn.the.material.", "I.prefer.when.the.leadership.i
f6 <- dat[, c("When.I.work.with.other.students.the.work.is.divided.equally.", "When.I.work.in.a.group..
f7 <- dat[, c("I.learn.to.work.with.students.who.are.different.from.me.", "I.also.learn.when.I.teach.the

alpha(f1, check.keys=TRUE)$total[1]
```

```
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
## In smc, smcs < 0 were set to .0
```

```
##  raw_alpha
##  0.8296734
```

```
alpha(f2, check.keys=TRUE)$total[1]
```

```
##  raw_alpha
##  0.7513288
```

```r
alpha(f3, check.keys=TRUE)$total[1]
```

```
##  raw_alpha
##  0.5518611
```

```r
alpha(f4, check.keys=TRUE)$total[1]
```

```
##  raw_alpha
##   0.764652
```

```r
alpha(f5, check.keys=TRUE)$total[1]
```

```
##  raw_alpha
##  0.6333324
```

```r
alpha(f6, check.keys=TRUE)$total[1]
```

```
##  raw_alpha
##  0.6224682
```

```r
alpha(f7, check.keys=TRUE)$total[1]
```

```
##  raw_alpha
##  0.4832298
```

3.8 Rating Scale

Now we want to give each student a rating for each factor based on their responses

```r
key.list <- list(
  f1=c("When.I.work.in.a.group..I.do.higher.quality.work.", "The.work.takes.more.time.to.complete.when.
  f2=c("You.have.a.certain.amount.of.physics.intelligence..and.you.can.t.really.do.much.to.change.it.",
  f3=c("I.have.to.work.with.students.who.are.not.as.smart.as.I.am.", "I.become.frustrated.when.my.group
  f4=c("My.group.members.respect.my.opinions.", "My.group.members.make.me.feel.that.I.am.not.as.smart.as
  f5=c("I.try.to.make.sure.my.group.members.learn.the.material.", "I.prefer.when.the.leadership.role.ro
  f6=c("When.I.work.with.other.students.the.work.is.divided.equally.", "When.I.work.in.a.group..I.end.up
  f7=c("I.learn.to.work.with.students.who.are.different.from.me.", "I.also.learn.when.I.teach.the.materi
)

keys <- make.keys(dat,key.list,item.labels=colnames(dat))
keys.list <- keys2list(keys,sign=TRUE)
scores <- scoreItems(keys.list,dat)
```

4 Linear Regression

First need to combine the item scores with the demographic info. (Columns 1, 55 (intervention) are course information, Columns 56-58 are demographics questions)

```r
df.lr <- cbind(scores$scores,raw_df[,c(1,55,56,57,58)])
df.lr <- df.lr[-(which(df.lr$Gender_group %in% "Drop")),]
df.lr <- df.lr[-(which(df.lr$Raceethnicity_group %in% "Drop")),]
df.lr <- df.lr[-(which(df.lr$Education_group %in% "Drop")),]
write.csv(df.lr,"R_scores.csv")
```

4.1 Models

```
f1.model <- lm(f1 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f1.model)
```

```
##
## Call:
## lm(formula = f1 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.62810 -0.12810 -0.00375  0.13094  0.51476
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     0.185492   0.016015  11.582  < 2e-16 ***
## CoursePHY105N                  -0.001463   0.010991  -0.133  0.89413
## Gender_groupOther              -0.043359   0.034137  -1.270  0.20428
## Gender_groupWoman               0.040711   0.011172   3.644  0.00028 ***
## Education_groupNot1stGen       -0.008167   0.012721  -0.642  0.52095
## InterventionControl             0.005755   0.013119   0.439  0.66096
## InterventionPartner Agreements -0.018504   0.013576  -1.363  0.17313
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1865 on 1218 degrees of freedom
## Multiple R-squared:  0.01733,    Adjusted R-squared:  0.01249
## F-statistic:  3.58 on 6 and 1218 DF,  p-value: 0.001602
```

```
f2.model <- lm(f2 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f2.model)
```

```
##
## Call:
## lm(formula = f2 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.83949 -0.15460 -0.02244  0.11842  1.18790
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    -0.163327   0.022405  -7.290 5.58e-13 ***
## CoursePHY105N                   0.005516   0.015376   0.359    0.720
## Gender_groupOther               0.031471   0.047758   0.659    0.510
## Gender_groupWoman               0.012707   0.015630   0.813    0.416
## Education_groupNot1stGen       -0.015407   0.017796  -0.866    0.387
## InterventionControl            -0.024573   0.018353  -1.339    0.181
## InterventionPartner Agreements -0.011533   0.018993  -0.607    0.544
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2609 on 1218 degrees of freedom
```

```
## Multiple R-squared:  0.00293,    Adjusted R-squared:  -0.001982
## F-statistic: 0.5965 on 6 and 1218 DF,  p-value: 0.7334
```

```
f3.model <- lm(f3 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f3.model)
```

```
##
## Call:
## lm(formula = f3 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.84534 -0.31951  0.00228  0.28449  1.36045
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    -0.32582    0.03923  -8.306 2.62e-16 ***
## CoursePHY105N                  -0.01815    0.02692  -0.674 0.500218
## Gender_groupOther               0.02584    0.08362   0.309 0.757393
## Gender_groupWoman              -0.05036    0.02737  -1.840 0.065967 .
## Education_groupNot1stGen        0.11144    0.03116   3.577 0.000362 ***
## InterventionControl             0.03389    0.03213   1.054 0.291880
## InterventionPartner Agreements -0.01974    0.03326  -0.594 0.552819
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4568 on 1218 degrees of freedom
## Multiple R-squared:  0.01597,    Adjusted R-squared:  0.01113
## F-statistic: 3.295 on 6 and 1218 DF,  p-value: 0.003204
```

```
f4.model <- lm(f4 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f4.model)
```

```
##
## Call:
## lm(formula = f4 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.64327 -0.06608  0.01671  0.10321  0.69237
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    0.0629962  0.0124402   5.064 4.74e-07 ***
## CoursePHY105N                 -0.0061386  0.0085373  -0.719    0.472
## Gender_groupOther             -0.0050226  0.0265169  -0.189    0.850
## Gender_groupWoman             -0.0089886  0.0086784  -1.036    0.301
## Education_groupNot1stGen       0.0036270  0.0098810   0.367    0.714
## InterventionControl           -0.0005439  0.0101904  -0.053    0.957
## InterventionPartner Agreements 0.0058228  0.0105456   0.552    0.581
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.1449 on 1218 degrees of freedom
## Multiple R-squared:  0.001605,   Adjusted R-squared:  -0.003313
## F-statistic: 0.3263 on 6 and 1218 DF,  p-value: 0.9234
```

```
f5.model <- lm(f5 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f5.model)
```

```
##
## Call:
## lm(formula = f5 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.20630 -0.19677  0.01571  0.20323  0.72303
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     0.38148    0.02549  14.965  < 2e-16 ***
## CoursePHY105N                  -0.05084    0.01749  -2.906  0.00373 **
## Gender_groupOther              -0.09690    0.05434  -1.783  0.07478 .
## Gender_groupWoman               0.02933    0.01778   1.649  0.09941 .
## Education_groupNot1stGen       -0.03387    0.02025  -1.673  0.09464 .
## InterventionControl             0.00736    0.02088   0.352  0.72455
## InterventionPartner Agreements -0.01980    0.02161  -0.916  0.35982
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2968 on 1218 degrees of freedom
## Multiple R-squared:  0.01824,    Adjusted R-squared:  0.01341
## F-statistic: 3.772 on 6 and 1218 DF,  p-value: 0.0009989
```

```
f6.model <- lm(f6 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f6.model)
```

```
##
## Call:
## lm(formula = f6 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.89628 -0.17428  0.01457  0.18123  0.87254
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    0.107113   0.024337   4.401 1.17e-05 ***
## CoursePHY105N                  0.009605   0.016702   0.575  0.56532
## Gender_groupOther             -0.028933   0.051875  -0.558  0.57713
## Gender_groupWoman              0.042529   0.016978   2.505  0.01238 *
## Education_groupNot1stGen       0.024638   0.019330   1.275  0.20270
## InterventionControl           -0.022178   0.019936  -1.112  0.26614
## InterventionPartner Agreements 0.055338   0.020630   2.682  0.00741 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 0.2834 on 1218 degrees of freedom
## Multiple R-squared:  0.02213,    Adjusted R-squared:  0.01731
## F-statistic: 4.594 on 6 and 1218 DF,  p-value: 0.0001272
```

```
f7.model <- lm(f7 ~ Course + Gender_group + Education_group + Intervention, data = df.lr)
summary(f7.model)
```

```
##
## Call:
## lm(formula = f7 ~ Course + Gender_group + Education_group + Intervention,
##     data = df.lr)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.47084 -0.16908  0.01848  0.19583  0.55214
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     0.473619   0.026616  17.794   <2e-16 ***
## CoursePHY105N                   0.014292   0.018266   0.782    0.434
## Gender_groupOther              -0.116083   0.056734  -2.046    0.041 *
## Gender_groupWoman               0.016584   0.018568   0.893    0.372
## Education_groupNot1stGen       -0.017075   0.021141  -0.808    0.419
## InterventionControl             0.014999   0.021803   0.688    0.492
## InterventionPartner Agreements -0.008684   0.022563  -0.385    0.700
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3099 on 1218 degrees of freedom
## Multiple R-squared:  0.006579,   Adjusted R-squared:  0.001686
## F-statistic: 1.344 on 6 and 1218 DF,  p-value: 0.2342
```