

Import necessary libraries

```
library(data.table)
library(tidyverse)
library(broom)
library(lmerTest)
library(mice)
library(miceadds)
library(MuMIn)
library(stargazer)
library(lattice)
library(simr)
library(car)
library(tableone)
```

Functions for processing and analyses

Load data and releval factors

```
Load.Clean.Data <- function(File = 'OVB_Master.csv', assessment, impute = FALSE) {
  # read in Master file, filter for particular assessment, and perform some data cleaning
  # also impute data if desired

  vars <- c('Class_Standing', 'Gender', 'URM_Status', 'First_Gen_Status',
            'AP_Calculus_AB', 'AP_Calculus_BC', 'ACT_SAT_Math_Percentile', 'PreScores',
            'PostScores', 'Semester', 'Sequence', 'Course_Content', 'Class_ID')

  df <- fread(File)
  if(impute){
    vars <- append(vars, 'GPA')
    df.assessment <- df[Assessment == assessment]
  } else { # only get matched data if not imputing
    df.assessment <- df[Assessment == assessment & (!is.na(PreScores) &
                                                    !is.na(PostScores))]
  }

  df.assessment <- df.assessment %>%
    select(vars) %>%
    mutate(Class_Standing = releval(as.factor(case_when(
      Class_Standing == 'Fresh' ~ 'FY',
      Class_Standing == 'Sophomore' | Class_Standing == 'Junior' |
      Class_Standing == 'Senior' ~ 'BFY',
      TRUE ~ NA_character_
    )), ref = 'FY'),
    Gender = releval(as.factor(Gender), ref = 'M'),
    URM_Status = releval(as.factor(URM_Status), ref = 'Majority'),
    First_Gen_Status = releval(as.factor(First_Gen_Status), ref = 'ContGen'),
    AP_Calculus_AB = releval(as.factor(AP_Calculus_AB), ref = 'NotTaken'),
    AP_Calculus_BC = releval(as.factor(AP_Calculus_BC), ref = 'NotTaken'),
```

```

Semester = relevel(as.factor(Semester), ref = 'FA'),
Sequence = relevel(as.factor(Sequence), ref = 'Engineering'),
Course_Content = as.factor(Course_Content),
Class_ID = as.factor(Class_ID),
ACT_SAT_Math_Percentile = c(scale(ACT_SAT_Math_Percentile, scale = TRUE)),
PreScores = c(scale(PreScores, scale = TRUE)),
PostScores = c(scale(PostScores, scale = TRUE)))

if(impute){
  levels(df.assessment$Class_ID) <- 1:length(levels(df.assessment$Class_ID))
  df.assessment$Class_ID <- as.numeric(df.assessment$Class_ID)

  Frac.Missing <- round(sum(is.na(df.assessment$PreScores) |
                           is.na(df.assessment$PostScores))/
                        nrow(df.assessment) * 100)
  print('% of students without matched data:')
  print(Frac.Missing)

  ini <- mice(df.assessment, maxit = 0)
  predM <- ini$predictorMatrix
  iniM <- ini$method

  predM[, 'Class_ID'] <- -2 # Class_ID is the grouping variable
  # 2l.pmmm of noth pretest and posttest scores
  iniM <- c(' ', ' ', ' ', ' ', ' ', ' ', ' ', '2l.pmm', '2l.pmm', ' ', ' ', ' ', ' ', ' ')

  set.seed(11)
  # we impute Frac.Missing datasets as recommended by Rubin
  imp.dat <- mice(df.assessment, m = Frac.Missing, pred = predM, met = iniM,
                 print = FALSE)
  return(imp.dat)
}
return(df.assessment)
}

```

Function to perform all fits

```

Do.Regressions <- function(dat, assessment) {
  # run nine regressions with posttest score as the dependent variable. Print R2 and AIC
  # for each model to compare fit statistics with coefficient estimates

  fit0 <- lmer(PostScores ~ (1 | Class_ID), dat)
  print(summary(fit0))
  print(r.squaredGLMM(fit0))
  print(AIC(fit0))

  fit1a <- lmer(PostScores ~ Gender + (1 | Class_ID), dat)
  print(summary(fit1a))
  print(r.squaredGLMM(fit1a))
  print(AIC(fit1a))
}

```

```

fit1b <- lmer(PostScores ~ URM_Status + (1 | Class_ID), dat)
print(summary(fit1b))
print(r.squaredGLMM(fit1b))
print(AIC(fit1b))

fit1c <- lmer(PostScores ~ Class_Standing + (1 | Class_ID), dat)
print(summary(fit1c))
print(r.squaredGLMM(fit1c))
print(AIC(fit1c))

fit1d <- lmer(PostScores ~ First_Gen_Status + (1 | Class_ID), dat)
print(summary(fit1d))
print(r.squaredGLMM(fit1d))
print(AIC(fit1d))

fit2 <- lmer(PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
              (1 | Class_ID), dat)
print(summary(fit2))
print(r.squaredGLMM(fit2))
print(AIC(fit2))

fit3 <- lmer(PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
              PreScores + (1 | Class_ID), dat)
print(summary(fit3))
print(r.squaredGLMM(fit3))
print(AIC(fit3))

fit4 <- lmer(PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
              PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
              (1 | Class_ID), dat)
print(summary(fit4))
print(r.squaredGLMM(fit4))
print(AIC(fit4))

if(assessment == 'PLIC' | assessment == 'ECLASS'){
  # E-CLASS and PLIC have mechanics and EM courses
  dat$Course_Content <- relevel(dat$Course_Content, ref = 'Mechanics')
  fit5 <- lmer(PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
                PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB +
                AP_Calculus_BC + Semester + Sequence + Course_Content +
                (1 | Class_ID), dat, na.action = 'na.fail')
} else {
  # CSEM and MBT have only one or the other
  fit5 <- lmer(PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
                PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB +
                AP_Calculus_BC + Semester + Sequence + (1 | Class_ID), dat,
                na.action = 'na.fail')
}
print(summary(fit5))
print(r.squaredGLMM(fit5))
print(AIC(fit5))

# stargazer needs lmerMod class models... this is only a data structure thing and

```

```

# doesn't affect estimates or undertainties
class(fit0) <- "lmerMod"
class(fit1a) <- "lmerMod"
class(fit1b) <- "lmerMod"
class(fit1c) <- "lmerMod"
class(fit1d) <- "lmerMod"
class(fit2) <- "lmerMod"
class(fit3) <- "lmerMod"
class(fit4) <- "lmerMod"
class(fit5) <- "lmerMod"

stargazer(fit0, fit1a, fit1b, fit1c, fit1d, fit2, fit3, fit4, fit5,
          star.cutoffs = c(0.05, 0.01, 0.001), intercept.bottom = FALSE,
          out = paste(assessment, '.tex'), intercept.top = TRUE, omit.stat = 'all')

# make a nice long format table of coefficients and estimates with model ID
Coefs.summary <- rbind(rbind(tidy(fit1a), tidy(fit1b), tidy(fit1c),
                                tidy(fit1d)) %>% mutate(Model = 1),
                      tidy(fit2) %>% mutate(Model = 2),
                      tidy(fit3) %>% mutate(Model = 3),
                      tidy(fit5) %>% mutate(Model = 5))

return(list("model" = fit5, "dataframe" = dat, 'Coefs' = Coefs.summary))
}

```

Descriptive statistics by assessment

```

df = read.csv('OVB_Master.csv')

vars = c("PreScores", "PostScores", "ACT_SAT_Math_Percentile", "Gender", "URM_Status", "Class_Standing")

CreateTableOne(vars = vars, strata = c("Assessment"), data = df[!is.na(df$PreScores) & !is.na(df$PostScores), ])

```

		Stratified by Assessment	
		CSEM	ECLASS
##	n	587	683
##	PreScores (mean (SD))	15.81 (6.27)	17.18 (6.64)
##	PostScores (mean (SD))	21.29 (6.71)	14.91 (8.41)
##	ACT_SAT_Math_Percentile (mean (SD))	98.26 (1.88)	98.35 (2.08)
##	Gender = M (%)	310 (52.8)	386 (56.5)
##	URM_Status = URM (%)	96 (16.4)	127 (18.6)
##	Class_Standing (%)		
##	Fresh	232 (39.5)	378 (55.3)
##	Junior	13 (2.2)	12 (1.8)
##	Senior	13 (2.2)	12 (1.8)
##	Sophomore	329 (56.0)	281 (41.1)
##	First_Gen_Status = FirstGen (%)	53 (9.0)	62 (9.1)
##	AP_Calculus_AB (%)		
##	NotTaken	118 (20.1)	149 (21.8)
##	Poor	21 (3.6)	20 (2.9)

##	Well	448 (76.3)	514 (75.3)	
##	AP_Calculus_BC (%)			
##	NotTaken	191 (32.5)	219 (32.1)	
##	Poor	19 (3.2)	21 (3.1)	
##	Well	377 (64.2)	443 (64.9)	
##	Semester = SP (%)	269 (45.8)	114 (16.7)	
##	Sequence = Honours (%)	123 (21.0)	197 (28.8)	
##	Course_Content = Mechanics (%)	0 (0.0)	347 (50.8)	
##		Stratified by Assessment		
##		MBT	PLIC	p
##	n	600	747	
##	PreScores (mean (SD))	13.82 (4.24)	5.30 (1.06)	<0.001
##	PostScores (mean (SD))	16.52 (4.30)	5.75 (1.11)	<0.001
##	ACT_SAT_Math_Percentile (mean (SD))	98.14 (1.90)	98.29 (1.92)	0.286
##	Gender = M (%)	257 (42.8)	357 (47.8)	<0.001
##	URM_Status = URM (%)	154 (25.7)	156 (20.9)	0.001
##	Class_Standing (%)			<0.001
##	Fresh	570 (95.0)	616 (82.5)	
##	Junior	5 (0.8)	9 (1.2)	
##	Senior	1 (0.2)	4 (0.5)	
##	Sophomore	24 (4.0)	118 (15.8)	
##	First_Gen_Status = FirstGen (%)	77 (12.8)	85 (11.4)	0.077
##	AP_Calculus_AB (%)			0.001
##	NotTaken	160 (26.7)	186 (24.9)	
##	Poor	38 (6.3)	25 (3.3)	
##	Well	402 (67.0)	536 (71.8)	
##	AP_Calculus_BC (%)			<0.001
##	NotTaken	284 (47.3)	286 (38.3)	
##	Poor	45 (7.5)	34 (4.6)	
##	Well	271 (45.2)	427 (57.2)	
##	Semester = SP (%)	509 (84.8)	351 (47.0)	<0.001
##	Sequence = Honours (%)	32 (5.3)	144 (19.3)	<0.001
##	Course_Content = Mechanics (%)	600 (100.0)	668 (89.4)	<0.001
##		Stratified by Assessment		
##		test		
##	n			
##	PreScores (mean (SD))			
##	PostScores (mean (SD))			
##	ACT_SAT_Math_Percentile (mean (SD))			
##	Gender = M (%)			
##	URM_Status = URM (%)			
##	Class_Standing (%)			
##	Fresh			
##	Junior			
##	Senior			
##	Sophomore			
##	First_Gen_Status = FirstGen (%)			
##	AP_Calculus_AB (%)			
##	NotTaken			
##	Poor			
##	Well			
##	AP_Calculus_BC (%)			
##	NotTaken			
##	Poor			

```
##      Well
##      Semester = SP (%)
##      Sequence = Honours (%)
##      Course_Content = Mechanics (%)
```

Regressions

CSEM regressions

```
df.CSEM <- Load.Clean.Data(assessment = 'CSEM')

df.CSEM.fit5 <- Do.Regressions(df.CSEM, assessment = 'CSEM')

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ (1 | Class_ID)
##      Data: dat
##
## REML criterion at convergence: 1588.2
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -3.4030 -0.5344  0.1202  0.7613  1.8951
##
## Random effects:
##      Groups      Name      Variance Std.Dev.
##  Class_ID (Intercept) 0.2037   0.4513
##      Residual          0.8457   0.9196
## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)   0.1767     0.1768 6.1064      1   0.355
##      R2m      R2c
## [1,]    0 0.1940813
## [1] 1594.232
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Gender + (1 | Class_ID)
##      Data: dat
##
## REML criterion at convergence: 1557.5
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -3.7531 -0.5477  0.1323  0.6654  2.0593
##
## Random effects:
##      Groups      Name      Variance Std.Dev.
##  Class_ID (Intercept) 0.1447   0.3804
##      Residual          0.8015   0.8953
```

```

## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##           Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  0.36481    0.15403   6.64696   2.368   0.0516 .
## GenderF      -0.45917    0.07735  584.57822  -5.936   5e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##           (Intr)
## GenderF -0.209
##           R2m      R2c
## [1,] 0.05269307 0.1975362
## [1] 1565.471
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ URM_Status + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1589.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.4243 -0.5640  0.1048  0.7473  2.0068
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1991  0.4462
## Residual 0.8451  0.9193
## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##           Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  0.1944    0.1755   6.1854   1.108   0.309
## URM_StatusURM -0.1291    0.1033  580.0251  -1.251   0.212
##
## Correlation of Fixed Effects:
##           (Intr)
## URM_SttsURM -0.081
##           R2m      R2c
## [1,] 0.002183928 0.1924586
## [1] 1597.372
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Class_Standing + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1565.9
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.6438 -0.5565  0.1423  0.7959  1.9643
##

```

```

## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.0832   0.2884
##   Residual              0.8187   0.9048
## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##               Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.4870    0.1328    7.6207   3.667  0.00689 **
## Class_StandinBFY -0.6404    0.1218  132.0236  -5.259 5.68e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## Clss_StnBFY -0.461
##              R2m      R2c
## [1,] 0.09819543 0.181388
## [1] 1573.948
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ First_Gen_Status + (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 1590.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.3988 -0.5320  0.1219  0.7626  1.8954
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.2041   0.4518
##   Residual              0.8471   0.9204
## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##               Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.17538    0.17726    6.14363   0.989   0.360
## First_Gen_StatusFirstGen  0.01787    0.13339  580.14750   0.134   0.893
##
## Correlation of Fixed Effects:
##              (Intr)
## Frst_Gn_SFG -0.057
##              R2m      R2c
## [1,] 2.499124e-05 0.1941872
## [1] 1598.406
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   (1 | Class_ID)
##   Data: dat
##

```



```

## REML criterion at convergence: 1533.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.0798 -0.5768  0.0972  0.7168  2.0726
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.03676  0.1917
##   Residual              0.77245  0.8789
## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.70057    0.10641    8.63780   6.584 0.000122
## GenderF          -0.50377    0.07739   570.63040  -6.510 1.65e-10
## URM_StatusURM    -0.21431    0.10233   579.74248  -2.094 0.036663
## Class_StandingBFY -0.60488    0.11103    48.90272  -5.448 1.65e-06
## First_Gen_StatusFirstGen -0.04300    0.12854   579.32931  -0.335 0.738118
##
## (Intercept)      ***
## GenderF           ***
## URM_StatusURM     *
## Class_StandingBFY ***
## First_Gen_StatusFirstGen
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) GendrF URM_SU C_SBFY
## GenderF      -0.306
## URM_SttsURM  -0.122  0.206
## Clss_StnBFY  -0.488 -0.072 -0.131
## Frst_Gn_SFG  -0.107  0.064 -0.112  0.013
## convergence code: 0
## Model failed to converge with max|grad| = 0.00215124 (tol = 0.002, component 1)
##
##              R2m      R2c
## [1,] 0.180611 0.2178347
## [1] 1547.748
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   PreScores + (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 1379.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.5673 -0.4666  0.1138  0.6278  2.2606
##
## Random effects:

```

```

## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.0000 0.0000
## Residual 0.5965 0.7724
## Number of obs: 587, groups: Class_ID, 7
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.23097 0.06821 581.00000 3.386 0.000756
## GenderF -0.21927 0.07036 581.00000 -3.116 0.001922
## URM_StatusURM -0.09980 0.09004 581.00000 -1.108 0.268135
## Class_StandingBFY -0.19809 0.07497 581.00000 -2.642 0.008457
## First_Gen_StatusFirstGen 0.09543 0.11307 581.00000 0.844 0.399016
## PreScores 0.53777 0.03908 581.00000 13.762 < 2e-16
##
## (Intercept) ***
## GenderF **
## URM_StatusURM
## Class_StandingBFY **
## First_Gen_StatusFirstGen
## PreScores ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr) GendrF URM_SU C_SBFY F_G_SF
## GenderF -0.554
## URM_SttsURM -0.243 0.219
## Clss_StnBFY -0.651 0.011 -0.097
## Frst_Gn_SFG -0.178 0.087 -0.103 0.012
## PreScores -0.508 0.347 0.110 0.451 0.104
## convergence code: 0
## boundary (singular) fit: see ?isSingular
##
## R2m R2c
## [1,] 0.4064803 0.4064803
## [1] 1395.087
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
## PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
## (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1361.9
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -4.6608 -0.5180 0.1218 0.6223 2.4247
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.0000 0.0000
## Residual 0.5706 0.7554

```

```

## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.11660    0.10072 576.00000    1.158  0.24748
## GenderF          -0.20641    0.06922 576.00000   -2.982  0.00298
## URM_StatusURM      0.01057    0.09290 576.00000    0.114  0.90948
## Class_StandingBFY -0.15704    0.07909 576.00000   -1.986  0.04755
## First_Gen_StatusFirstGen 0.15514    0.11204 576.00000    1.385  0.16667
## PreScores         0.51563    0.03872 576.00000   13.317 < 2e-16
## ACT_SAT_Math_Percentile 0.07331    0.03557 576.00000    2.061  0.03973
## AP_Calculus_ABPoor -0.60317    0.20765 576.00000   -2.905  0.00382
## AP_Calculus_ABWell  0.23604    0.11652 576.00000    2.026  0.04324
## AP_Calculus_BCPoor -0.14475    0.21104 576.00000   -0.686  0.49306
## AP_Calculus_BCWell -0.14612    0.10643 576.00000   -1.373  0.17028
##
## (Intercept)
## GenderF          **
## URM_StatusURM
## Class_StandingBFY      *
## First_Gen_StatusFirstGen
## PreScores          ***
## ACT_SAT_Math_Percentile *
## AP_Calculus_ABPoor    **
## AP_Calculus_ABWell    *
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) GendrF URM_SU C_SBFY F_G_SF PrScrs ACT_SA AP_C_ABP
## GenderF      -0.316
## URM_SttsURM  -0.212  0.224
## Clss_StnBFY  -0.609  0.003 -0.036
## Frst_Gn_SFG  -0.111  0.088 -0.069  0.000
## PreScores    -0.330  0.335  0.063  0.411  0.077
## ACT_SAT_M_P   0.009  0.043  0.265  0.038  0.119 -0.146
## AP_Clcl_ABP  -0.177 -0.030 -0.010 -0.041 -0.045  0.031  0.072
## AP_Clcl_ABW  -0.370 -0.052  0.011 -0.065  0.050 -0.028 -0.040  0.326
## AP_Clcl_BCP   0.006 -0.048 -0.098  0.035  0.053 -0.022  0.011 -0.484
## AP_Clcl_BCW  -0.191 -0.002  0.015  0.290 -0.076  0.048 -0.094 -0.173
##              AP_C_ABW AP_C_BCP
## GenderF
## URM_SttsURM
## Clss_StnBFY
## Frst_Gn_SFG
## PreScores
## ACT_SAT_M_P
## AP_Clcl_ABP
## AP_Clcl_ABW
## AP_Clcl_BCP -0.232
## AP_Clcl_BCW -0.707  0.259
## convergence code: 0

```

```

## boundary (singular) fit: see ?isSingular
##
##           R2m           R2c
## [1,] 0.4349262 0.4349262
## [1] 1387.928
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
##   Semester + Sequence + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1367.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.6835 -0.5115  0.1213  0.6162  2.4295
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.0000   0.0000
##   Residual              0.5723   0.7565
## Number of obs: 587, groups:  Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.128994   0.151511 574.000000    0.851  0.39491
## GenderF          -0.210500   0.069800 574.000000   -3.016  0.00268
## URM_StatusURM      0.008384   0.093144 574.000000    0.090  0.92831
## Class_StandingBFY -0.159891   0.121263 574.000000   -1.319  0.18785
## First_Gen_StatusFirstGen 0.153146   0.112643 574.000000    1.360  0.17450
## PreScores         0.524032   0.042430 574.000000   12.351 < 2e-16
## ACT_SAT_Math_Percentile 0.072885   0.036373 574.000000    2.004  0.04556
## AP_Calculus_ABPoor -0.603577   0.208206 574.000000   -2.899  0.00389
## AP_Calculus_ABWell  0.233179   0.116971 574.000000    1.993  0.04668
## AP_Calculus_BCPoor -0.147895   0.211718 574.000000   -0.699  0.48512
## AP_Calculus_BCWell -0.144525   0.106691 574.000000   -1.355  0.17608
## SemesterSP        0.007255   0.110017 574.000000    0.066  0.94745
## SequenceHonours   -0.048914   0.097090 574.000000   -0.504  0.61460
##
## (Intercept)
## GenderF          **
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen
## PreScores       ***
## ACT_SAT_Math_Percentile *
## AP_Calculus_ABPoor **
## AP_Calculus_ABWell *
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## SemesterSP
## SequenceHonours

```

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## convergence code: 0
## boundary (singular) fit: see ?isSingular
##
##           R2m           R2c
## [1,] 0.4343202 0.4343202
## [1] 1397.081
##
## % Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
## % Date and time: Mon, Aug 17, 2020 - 3:16:35 PM
## \begin{table}[!htbp] \centering
##   \caption{}
##   \label{}
## \begin{tabular}{@{\extracolsep{5pt}}lcccccccc}
## \hline \hline
## \hline \hline
## & \multicolumn{9}{c}{\textit{Dependent variable:}} \hline
## \cline{2-10}
## \hline \hline
## & \multicolumn{9}{c}{PostScores} \hline
## \hline \hline
## & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) & (9) \hline
## \hline \hline
## Constant & 0.177 & 0.365$^{*}$ & 0.194 & 0.487$^{***}$ & 0.175 & 0.701$^{***}$ & 0.231$^{***}$ & 0.152$^{***}$ & 0.152$^{***}$ \hline
## & (0.177) & (0.154) & (0.176) & (0.133) & (0.177) & (0.106) & (0.068) & (0.101) & (0.152) \hline
## & & & & & & & & & \hline
## GenderF & & $-0.459$^{***}$ & & & & $-0.504$^{***}$ & $-0.219$^{**}$ & $-0.206$^{**}$ & $-0.152$^{***}$ \hline
## & & (0.077) & & & & (0.077) & (0.070) & (0.069) & (0.070) \hline
## & & & & & & & & & \hline
## URM\_StatusURM & & & $-0.129$ & & & $-0.214$^{*}$ & $-0.100$ & 0.011 & 0.008 \hline
## & & & (0.103) & & & (0.102) & (0.090) & (0.093) & (0.093) \hline
## & & & & & & & & & \hline
## Class\_StandingBFY & & & & $-0.640$^{***}$ & & & $-0.605$^{***}$ & $-0.198$^{**}$ & $-0.157$^{***}$ \hline
## & & & & (0.122) & & & (0.111) & (0.075) & (0.079) & (0.121) \hline
## & & & & & & & & & \hline
## First\_Gen\_StatusFirstGen & & & & 0.018 & $-0.043$ & 0.095 & 0.155 & 0.153 \hline
## & & & & (0.133) & (0.129) & (0.113) & (0.112) & (0.113) \hline
## & & & & & & & & & \hline
## PreScores & & & & & 0.538$^{***}$ & 0.516$^{***}$ & 0.524$^{***}$ \hline
## & & & & & (0.039) & (0.039) & (0.042) \hline
## & & & & & & & & & \hline
## ACT\_SAT\_Math\_Percentile & & & & & & 0.073$^{*}$ & 0.073$^{*}$ \hline
## & & & & & & (0.036) & (0.036) \hline
## & & & & & & & & & \hline
## AP\_Calculus\_ABPoor & & & & & & & $-0.603$^{**}$ & $-0.604$^{**}$ \hline
## & & & & & & & (0.208) & (0.208) \hline
## & & & & & & & & & \hline
## AP\_Calculus\_ABWell & & & & & & & 0.236$^{*}$ & 0.233$^{*}$ \hline
## & & & & & & & (0.117) & (0.117) \hline
## & & & & & & & & & \hline
## AP\_Calculus\_BCPoor & & & & & & & $-0.145$ & $-0.148$ \hline
## & & & & & & & (0.211) & (0.212) \hline
## & & & & & & & & & \hline
## AP\_Calculus\_BCWell & & & & & & & $-0.146$ & $-0.145$ \hline
## & & & & & & & (0.106) & (0.107) \hline

```

```
## & & & & & & & & \\\n## SemesterSP & & & & & & & & 0.007 \\\n## & & & & & & & & (0.110) \\\n## & & & & & & & & \\\n## SequenceHonours & & & & & & & & $-$0.049 \\\n## & & & & & & & & (0.097) \\\n## & & & & & & & & \\\n## \\hline \\[-1.8ex]\n## \\hline\n## \\hline \\[-1.8ex]\n## \\textit{Note:} & \\multicolumn{9}{r}{\\$^{*}\\$p$<$0.05; \\$^{**}\\$p$<$0.01; \\$^{***}\\$p$<$0.001} \\\n## \\end{tabular}\n## \\end{table}
```

```
CSEM.Coeffs <- df.CSEM.fit5$Coeffs
```

```
png('Figures/DiagnosticPlots/CSEM_ResidFitted.png', width = 363, height = 363)\nplot(df.CSEM.fit5$model, xlab = 'Fitted values', ylab = 'Residuals')\ndev.off()
```

```
## pdf\n## 2
```

```
png('Figures/DiagnosticPlots/CSEM_qq.png', width = 363, height = 363)\nqqmath(df.CSEM.fit5$model)\ndev.off()
```

```
## pdf\n## 2
```

```
vif(df.CSEM.fit5$model)
```

	GVIF	Df	GVIF ^{1/(2*Df)}
Gender	1.245327	1	1.115942
URM_Status	1.217288	1	1.103308
Class_Standing	3.605012	1	1.898687
First_Gen_Status	1.068949	1	1.033900
PreScores	1.843340	1	1.357697
ACT_SAT_Math_Percentile	1.354642	1	1.163891
AP_Calculus_AB	3.067029	2	1.323364
AP_Calculus_BC	3.393769	2	1.357283
Semester	3.081963	1	1.755552
Sequence	1.601402	1	1.265465

E-CLASS regressions

```
df.ECLASS <- Load.Clean.Data(assessment = 'ECLASS')\ndf.ECLASS.fit5 <- Do.Regressions(df.ECLASS, assessment = 'ECLASS')
```

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1865
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.1639 -0.4900  0.1457  0.6669  2.0653
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1450  0.3808
## Residual 0.8744  0.9351
## Number of obs: 683, groups: Class_ID, 7
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.1771 0.1546 6.2229 1.146 0.294
## R2m R2c
## [1,] 0 0.1422246
## [1] 1871.039
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Gender + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1864.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.2460 -0.5259  0.1179  0.7200  2.1502
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1379  0.3713
## Residual 0.8711  0.9333
## Number of obs: 683, groups: Class_ID, 7
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.23490 0.15401 6.68191 1.525 0.1730
## GenderF -0.14482 0.07395 679.08231 -1.958 0.0506 .
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## GenderF -0.194
## R2m R2c
## [1,] 0.005089722 0.1410367
## [1] 1872.586
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [

```

```

## lmerModLmerTest]
## Formula: PostScores ~ URM_Status + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1865.4
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -4.0454 -0.5137 0.1226 0.6648 2.0979
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1403 0.3746
## Residual 0.8726 0.9341
## Number of obs: 683, groups: Class_ID, 7
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.19934 0.15295 6.32922 1.303 0.238
## URM_StatusURM -0.14835 0.09254 677.24008 -1.603 0.109
##
## Correlation of Fixed Effects:
## (Intr)
## URM_SttsURM -0.092
## R2m R2c
## [1,] 0.003283013 0.1413504
## [1] 1873.396
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Class_Standing + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1864.9
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -4.1568 -0.4979 0.1329 0.6744 1.9457
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1089 0.330
## Residual 0.8743 0.935
## Number of obs: 683, groups: Class_ID, 7
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.2355 0.1412 6.1827 1.668 0.1449
## Class_StandingBFY -0.1964 0.1179 336.1641 -1.666 0.0967 .
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## Clss_StnBFY -0.265

```



```

##              R2m      R2c
## [1,] 0.009613579 0.1192898
## [1] 1872.921
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ First_Gen_Status + (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 1866.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.0502 -0.4903  0.1344  0.6818  2.0528
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.1432   0.3784
##   Residual              0.8746   0.9352
## Number of obs: 683, groups:  Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.1861     0.1540   6.2781   1.208   0.270
## First_Gen_StatusFirstGen -0.1172     0.1248 676.4417  -0.939   0.348
##
## Correlation of Fixed Effects:
##              (Intr)
## Frst_Gn_SFG -0.063
##              R2m      R2c
## [1,] 0.001115144 0.141667
## [1] 1874.481
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 1865.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.0231 -0.4983  0.1451  0.6973  1.9886
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.1005   0.3171
##   Residual              0.8683   0.9318
## Number of obs: 683, groups:  Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.32971     0.14079   6.96574   2.342   0.0519 .
## GenderF          -0.17360     0.07545 676.91398  -2.301   0.0217 *

```

```

## URM_StatusURM          -0.17874    0.09481 674.87035 -1.885    0.0598 .
## Class_StandingBFY      -0.16649    0.11800 314.94933 -1.411    0.1592
## First_Gen_StatusFirstGen -0.09282    0.12502 673.92273 -0.742    0.4581
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) GendrF URM_SU C_SBFY
## GenderF      -0.226
## URM_SttsURM  -0.122  0.206
## Clss_StnBFY  -0.241 -0.045 -0.086
## Frst_Gn_SFG  -0.045  0.006 -0.058 -0.078
##      R2m      R2c
## [1,] 0.02108076 0.122649
## [1] 1879.48
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   PreScores + (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 1577.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -5.0481 -0.5696  0.1537  0.6775  2.1031
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.05508  0.2347
##   Residual              0.56504  0.7517
## Number of obs: 683, groups:  Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.23106    0.10654    6.61800   2.169    0.069
## GenderF          -0.08755    0.06101   676.17826  -1.435    0.152
## URM_StatusURM    -0.09509    0.07660   673.88267  -1.241    0.215
## Class_StandingBFY -0.10017    0.09449   257.68035  -1.060    0.290
## First_Gen_StatusFirstGen -0.02256    0.10091   672.79181  -0.224    0.823
## PreScores         0.56460    0.02950   675.62239  19.138 <2e-16
##
## (Intercept)      .
## GenderF
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen
## PreScores          ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) GendrF URM_SU C_SBFY F_G_SF

```

```

## GenderF      -0.243
## URM_SttsURM -0.133  0.209
## Clss_StnBFY -0.254 -0.044 -0.084
## Frst_Gn_SFG -0.051  0.009 -0.056 -0.076
## PreScores   -0.049  0.074  0.057  0.042  0.036
##           R2m      R2c
## [1,] 0.3529015 0.4103763
## [1] 1593.561
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
##   (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1589.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -5.0126 -0.5555  0.1406  0.6616  2.0813
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.05194 0.2279
## Residual 0.56748 0.7533
## Number of obs: 683, groups: Class_ID, 7
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.25652    0.12286   12.19027   2.088  0.0584
## GenderF          -0.08003    0.06144  671.25247  -1.303  0.1931
## URM_StatusURM    -0.08484    0.07784  668.77205  -1.090  0.2762
## Class_StandingBFY -0.11430    0.10246  217.11977  -1.116  0.2659
## First_Gen_StatusFirstGen -0.02234    0.10121  667.60886  -0.221  0.8254
## PreScores         0.56372    0.02958  670.65376  19.059 <2e-16
## ACT_SAT_Math_Percentile 0.01153    0.03132  671.72208   0.368  0.7128
## AP_Calculus_ABPoor -0.06766    0.20830  666.70553  -0.325  0.7454
## AP_Calculus_ABWell  0.06753    0.11222  669.07876   0.602  0.5475
## AP_Calculus_BCPoor -0.18317    0.20073  667.16140  -0.913  0.3618
## AP_Calculus_BCWell -0.11224    0.10650  671.27425  -1.054  0.2923
##
## (Intercept)      .
## GenderF
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen
## PreScores      ***
## ACT_SAT_Math_Percentile
## AP_Calculus_ABPoor
## AP_Calculus_ABWell
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## ---

```

```

## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr) GendrF URM_SU C_SBFY F_G_SF PrScrs ACT_SA AP_C_ABP
## GenderF      -0.210
## URM_SttsURM  -0.138  0.214
## Clss_StnBFY  -0.344 -0.037 -0.036
## Frst_Gn_SFG  -0.060  0.008 -0.052 -0.061
## PreScores    -0.049  0.073  0.054  0.043  0.036
## ACT_SAT_M_P  -0.050  0.001  0.116  0.229  0.025 -0.007
## AP_Clcl_ABP  -0.107 -0.038 -0.088 -0.028  0.018  0.019  0.022
## AP_Clcl_ABW  -0.266  0.014  0.034 -0.011  0.031 -0.011  0.089  0.321
## AP_Clcl_BCP   0.007 -0.061  0.002  0.019 -0.003 -0.007 -0.011 -0.486
## AP_Clcl_BCW  -0.089 -0.018 -0.025  0.179 -0.016  0.023 -0.167 -0.187
##      AP_C_ABW AP_C_BCP
## GenderF
## URM_SttsURM
## Clss_StnBFY
## Frst_Gn_SFG
## PreScores
## ACT_SAT_M_P
## AP_Clcl_ABP
## AP_Clcl_ABW
## AP_Clcl_BCP -0.278
## AP_Clcl_BCW -0.758    0.307
##      R2m      R2c
## [1,] 0.3551982 0.4092653
## [1] 1615.464
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##      PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
##      Semester + Sequence + Course_Content + (1 | Class_ID)
##      Data: dat
##
## REML criterion at convergence: 1586.9
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -5.0270 -0.5463  0.1559  0.6582  2.4354
##
## Random effects:
##      Groups   Name      Variance Std.Dev.
##      Class_ID (Intercept) 0.0000   0.0000
##      Residual              0.5689   0.7542
## Number of obs: 683, groups:  Class_ID, 7
##
## Fixed effects:
##      Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.19508   0.09933 669.00000   1.964 0.049942
## GenderF          -0.06812   0.06126 669.00000  -1.112 0.266512
## URM_StatusURM    -0.07892   0.07776 669.00000  -1.015 0.310536
## Class_StandingBFY -0.06561   0.10342 669.00000  -0.634 0.526037

```

```

## First_Gen_StatusFirstGen -0.02112 0.10114 669.00000 -0.209 0.834621
## PreScores 0.55844 0.02956 669.00000 18.893 < 2e-16
## ACT_SAT_Math_Percentile 0.01371 0.03118 669.00000 0.440 0.660293
## AP_Calculus_ABPoor -0.06866 0.20846 669.00000 -0.329 0.741971
## AP_Calculus_ABWell 0.07749 0.11236 669.00000 0.690 0.490660
## AP_Calculus_BCPoor -0.17495 0.20087 669.00000 -0.871 0.384098
## AP_Calculus_BCWell -0.10119 0.10597 669.00000 -0.955 0.339974
## SemesterSP 0.22794 0.09675 669.00000 2.356 0.018763
## SequenceHonours 0.15436 0.08253 669.00000 1.870 0.061879
## Course_ContentEM -0.38100 0.10054 669.00000 -3.790 0.000165
##
## (Intercept) *
## GenderF
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen
## PreScores ***
## ACT_SAT_Math_Percentile
## AP_Calculus_ABPoor
## AP_Calculus_ABWell
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## SemesterSP *
## SequenceHonours .
## Course_ContentEM ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## convergence code: 0
## boundary (singular) fit: see ?isSingular
##
## R2m R2c
## [1,] 0.4372276 0.4372276
## [1] 1618.85
##
## % Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
## % Date and time: Mon, Aug 17, 2020 - 3:16:42 PM
## \begin{table}[!htbp] \centering
## \caption{}
## \label{}
## \begin{tabular}{@{\extracolsep{5pt}}lcccccccc}
## \ll[-1.8ex]\hline
## \hline \ll[-1.8ex]
## & \multicolumn{9}{c}{\textit{Dependent variable:}} \ll
## \cline{2-10}
## \ll[-1.8ex] & \multicolumn{9}{c}{PostScores} \ll
## \ll[-1.8ex] & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) & (9) \ll
## \hline \ll[-1.8ex]
## Constant & 0.177 & 0.235 & 0.199 & 0.236 & 0.186 & 0.330$^{[*]}$ & 0.231$^{[*]}$ & 0.257$^{[*]}$ & 0.195$^{[*]}$
## & (0.155) & (0.154) & (0.153) & (0.141) & (0.154) & (0.141) & (0.107) & (0.123) & (0.099) \ll
## & & & & & & & & & \ll
## GenderF & & $-$0.145 & & & & $-$0.174$^{[*]}$ & $-$0.088 & $-$0.080 & $-$0.068 \ll
## & & (0.074) & & & & (0.075) & (0.061) & (0.061) & (0.061) \ll
## & & & & & & & & & \ll
## URM\_StatusURM & & & $-$0.148 & & & $-$0.179 & $-$0.095 & $-$0.085 & $-$0.079 \ll

```

```

## & & & (0.093) & & & (0.095) & (0.077) & (0.078) & (0.078) \\
## & & & & & & & & \\
## Class\_StandingBFY & & & & $-$0.196 & & $-$0.166 & $-$0.100 & $-$0.114 & $-$0.066 \\
## & & & & (0.118) & & (0.118) & (0.094) & (0.102) & (0.103) \\
## & & & & & & & & \\
## First\_Gen\_StatusFirstGen & & & & $-$0.117 & $-$0.093 & $-$0.023 & $-$0.022 & $-$0.021 \\
## & & & & (0.125) & (0.125) & (0.101) & (0.101) & (0.101) \\
## & & & & & & & & \\
## PreScores & & & & & & 0.565$^{***}$ & 0.564$^{***}$ & 0.558$^{***}$ \\
## & & & & & & (0.030) & (0.030) & (0.030) \\
## & & & & & & & & \\
## ACT\_SAT\_Math\_Percentile & & & & & & 0.012 & 0.014 \\
## & & & & & & (0.031) & (0.031) \\
## & & & & & & & & \\
## AP\_Calculus\_ABPoor & & & & & & $-$0.068 & $-$0.069 \\
## & & & & & & (0.208) & (0.208) \\
## & & & & & & & & \\
## AP\_Calculus\_ABWell & & & & & & 0.068 & 0.077 \\
## & & & & & & (0.112) & (0.112) \\
## & & & & & & & & \\
## AP\_Calculus\_BCPoor & & & & & & $-$0.183 & $-$0.175 \\
## & & & & & & (0.201) & (0.201) \\
## & & & & & & & & \\
## AP\_Calculus\_BCWell & & & & & & $-$0.112 & $-$0.101 \\
## & & & & & & (0.107) & (0.106) \\
## & & & & & & & & \\
## SemesterSP & & & & & & 0.228$^{*}$ \\
## & & & & & & (0.097) \\
## & & & & & & & & \\
## SequenceHonours & & & & & & 0.154 \\
## & & & & & & (0.083) \\
## & & & & & & & & \\
## Course\_ContentEM & & & & & & $-$0.381$^{***}$ \\
## & & & & & & (0.101) \\
## & & & & & & & & \\
## \hline \\[-1.8ex]
## \hline
## \hline \\[-1.8ex]
## \textit{Note:} & \multicolumn{9}{r}{$^{*}$p<$0.05; $^{**}$p<$0.01; $^{***}$p<$0.001} \\
## \end{tabular}
## \end{table}

```

```
ECLASS.Coefs <- df.ECLASS.fit5$Coefs
```

```

png('Figures/DiagnosticPlots/ECLASS_ResidFitted.png', width = 363, height = 363)
plot(df.ECLASS.fit5$model, xlab = 'Fitted values', ylab = 'Residuals')
dev.off()

```

```

## pdf
## 2

```

```

png('Figures/DiagnosticPlots/ECLASS_qq.png', width = 363, height = 363)
qqmath(df.ECLASS.fit5$model)
dev.off()

```

```
## pdf
## 2
```

```
vif(df.ECLASS.fit5$model)
```

```
##              GVIF Df GVIF^(1/(2*Df))
## Gender          1.107257 1      1.052263
## URM_Status      1.099028 1      1.048345
## Class_Standing  3.173541 1      1.781444
## First_Gen_Status 1.013708 1      1.006831
## PreScores       1.047376 1      1.023414
## ACT_SAT_Math_Percentile 1.165207 1      1.079447
## AP_Calculus_AB   3.408555 2      1.358759
## AP_Calculus_BC   3.783988 2      1.394721
## Semester        1.562717 1      1.250087
## Sequence        1.678475 1      1.295560
## Course_Content   3.033204 1      1.741610
```

MBT regressions

```
df.MBT <- Load.Clean.Data(assessment = 'MBT')
```

```
df.MBT.fit5 <- Do.Regressions(df.MBT, assessment = 'MBT')
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1669.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.00261 -0.59041  0.05827  0.72692  2.11781
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1148  0.3388
## Residual            0.9281  0.9634
## Number of obs: 600, groups: Class_ID, 4
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)   0.1363     0.1774 3.1266   0.768   0.496
## R2m          R2c
## [1,]      0 0.1100506
## [1] 1675.432
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Gender + (1 | Class_ID)
## Data: dat
```

```

##
## REML criterion at convergence: 1661.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.1978 -0.5888  0.1273  0.6956  2.2885
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.1126   0.3355
##   Residual              0.9120   0.9550
## Number of obs: 600, groups:  Class_ID, 4
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   0.28348    0.18100   3.51966   1.566  0.20188
## GenderF      -0.26873    0.07896  595.87789  -3.403  0.00071 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr)
## GenderF -0.239
##          R2m      R2c
## [1,] 0.01699421 0.1250015
## [1] 1669.181
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ URM_Status + (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 1663.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.09608 -0.63052  0.05977  0.70467  2.09129
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.1044   0.3232
##   Residual              0.9164   0.9573
## Number of obs: 600, groups:  Class_ID, 4
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   0.1940    0.1710   3.2096   1.134  0.33417
## URM_StatusURM -0.2687    0.0901  596.4343  -2.983  0.00297 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr)
## URM_SttsURM -0.114
##          R2m      R2c

```



```

## [1,] 0.01334074 0.1142779
## [1] 1671.572
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Class_Standing + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1670.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.00643 -0.59437  0.05259  0.70002  2.11103
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1212  0.3481
## Residual 0.9282  0.9634
## Number of obs: 600, groups: Class_ID, 4
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.1467 0.1823 3.1313 0.805 0.478
## Class_StandingBFY -0.1633 0.1840 597.5344 -0.887 0.375
##
## Correlation of Fixed Effects:
## (Intr)
## Clss_StnBFY -0.062
## R2m R2c
## [1,] 0.00120696 0.1165561
## [1] 1678.197
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ First_Gen_Status + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1662.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.90374 -0.63044  0.01048  0.73904  2.04752
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.1105  0.3324
## Residual 0.9157  0.9569
## Number of obs: 600, groups: Class_ID, 4
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.1871 0.1751 3.1839 1.068 0.35953
## First_Gen_StatusFirstGen -0.3559 0.1173 596.6356 -3.033 0.00252 **
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##

```

```

## Correlation of Fixed Effects:
##          (Intr)
## Frst_Gn_SFG -0.096
##          R2m      R2c
## [1,] 0.01364422 0.1198263
## [1] 1670.735
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##          (1 | Class_ID)
##      Data: dat
##
## REML criterion at convergence: 1642.8
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.12531 -0.58370  0.04821  0.75569  2.24859
##
## Random effects:
##      Groups   Name      Variance Std.Dev.
##      Class_ID (Intercept) 0.1029   0.3208
##      Residual              0.8786   0.9374
## Number of obs: 600, groups:  Class_ID, 4
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.46815   0.17769    3.85234   2.635 0.060176
## GenderF          -0.35915   0.08061   593.42975  -4.455 1e-05
## URM_StatusURM    -0.34947   0.09155   593.91855  -3.817 0.000149
## Class_StandingBFY -0.22950   0.18013   594.70461  -1.274 0.203132
## First_Gen_StatusFirstGen -0.31913   0.11536   593.79502  -2.766 0.005847
##
## (Intercept)      .
## GenderF          ***
## URM_StatusURM    ***
## Class_StandingBFY
## First_Gen_StatusFirstGen **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr) GendrF URM_SU C_SBFY
## GenderF      -0.282
## URM_SttsURM  -0.167  0.254
## Clss_StnBFY  -0.089  0.108  0.007
## Frst_Gn_SFG  -0.078 -0.017 -0.085 -0.015
##          R2m      R2c
## [1,] 0.05390438 0.153098
## [1] 1656.77
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +

```

```

##      PreScores + (1 | Class_ID)
##      Data: dat
##
## REML criterion at convergence: 1479.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.8609 -0.5480  0.0563  0.6667  2.8800
##
## Random effects:
##      Groups   Name      Variance Std.Dev.
##      Class_ID (Intercept) 0.05777  0.2403
##      Residual      0.66408  0.8149
## Number of obs: 600, groups:  Class_ID, 4
##
## Fixed effects:
##
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.16039    0.13897    3.86172   1.154   0.3148
## GenderF          -0.09748    0.07254  591.52417  -1.344   0.1795
## URM_StatusURM    -0.18989    0.08040  592.31147  -2.362   0.0185
## Class_StandinBFY  0.07673    0.15800  593.99572   0.486   0.6274
## First_Gen_StatusFirstGen -0.20334    0.10062  593.22815  -2.021   0.0437
## PreScores        0.50097    0.03593  592.82674  13.944  <2e-16
##
## (Intercept)
## GenderF
## URM_StatusURM      *
## Class_StandinBFY
## First_Gen_StatusFirstGen *
## PreScores          ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) GendrF URM_SU C_SBFY F_G_SF
## GenderF      -0.345
## URM_SttsURM  -0.208  0.279
## Clss_StnBFY  -0.119  0.139  0.027
## Frst_Gn_SFG  -0.099  0.006 -0.072 -0.003
## PreScores    -0.158  0.259  0.143  0.137  0.083
##
##              R2m      R2c
## [1,] 0.2855556 0.3427302
## [1] 1495.217
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##      PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
##      (1 | Class_ID)
##      Data: dat
##
## REML criterion at convergence: 1490.4
##
## Scaled residuals:

```

```

##      Min      1Q  Median      3Q      Max
## -3.7787 -0.5419  0.0598  0.6636  2.9821
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.0567   0.2381
##   Residual              0.6653   0.8156
## Number of obs: 600, groups:  Class_ID, 4
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.08031   0.15010    5.32647   0.535   0.6142
## GenderF          -0.08866   0.07290  586.32810  -1.216   0.2244
## URM_StatusURM    -0.16446   0.08280  587.33228  -1.986   0.0475
## Class_StandingBFY  0.10800   0.16148  588.94067   0.669   0.5039
## First_Gen_StatusFirstGen -0.19900   0.10101  588.08411  -1.970   0.0493
## PreScores         0.49292   0.03713  588.38821  13.277 <2e-16
## ACT_SAT_Math_Percentile  0.03705   0.03682  587.01423   1.006   0.3148
## AP_Calculus_ABPoor  0.06764   0.16076  586.18336   0.421   0.6741
## AP_Calculus_ABWell  0.17220   0.10133  586.76443   1.699   0.0898
## AP_Calculus_BCPoor -0.08587   0.14491  586.13758  -0.593   0.5537
## AP_Calculus_BCWell -0.09881   0.09625  588.37597  -1.027   0.3050
##
## (Intercept)
## GenderF
## URM_StatusURM      *
## Class_StandingBFY
## First_Gen_StatusFirstGen *
## PreScores          ***
## ACT_SAT_Math_Percentile
## AP_Calculus_ABPoor
## AP_Calculus_ABWell      .
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) GendrF URM_SU C_SBFY F_G_SF PrScrs ACT_SA AP_C_ABP
## GenderF      -0.321
## URM_SttsURM  -0.227  0.276
## Clss_StnBFY  -0.122  0.140  0.071
## Frst_Gn_SFG  -0.096  0.009 -0.062  0.003
## PreScores    -0.120  0.246  0.080  0.080  0.075
## ACT_SAT_M_P  -0.026  0.048  0.182  0.166  0.014 -0.215
## AP_Clc1_ABP  -0.170  0.035 -0.041 -0.068  0.003  0.051  0.073
## AP_Clc1_ABW  -0.288  0.049  0.045 -0.010  0.007  0.020  0.032  0.399
## AP_Clc1_BCP  0.014 -0.063  0.002  0.017 -0.062 -0.042 -0.009 -0.371
## AP_Clc1_BCW -0.021 -0.067  0.035  0.039  0.010 -0.064 -0.136 -0.178
##              AP_C_ABW AP_C_BCP
## GenderF
## URM_SttsURM
## Clss_StnBFY
## Frst_Gn_SFG

```

```

## PreScores
## ACT_SAT_M_P
## AP_C1c1_ABP
## AP_C1c1_ABW
## AP_C1c1_BCP -0.328
## AP_C1c1_BCW -0.622    0.360
##          R2m          R2c
## [1,] 0.2883305 0.3442237
## [1] 1516.375
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
##   Semester + Sequence + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 1487.9
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7714 -0.5582  0.0547  0.6571  3.0031
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.01137  0.1066
##   Residual              0.66517  0.8156
## Number of obs: 600, groups:  Class_ID, 4
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.44479    0.16877    3.86576   2.636   0.0599
## GenderF          -0.09023    0.07291   586.05204  -1.238   0.2164
## URM_StatusURM    -0.16697    0.08284   586.29922  -2.016   0.0443
## Class_StandingBFY  0.08724    0.16191   586.29448   0.539   0.5902
## First_Gen_StatusFirstGen -0.19266    0.10114   586.00490  -1.905   0.0573
## PreScores        0.49275    0.03727   586.02087  13.223 <2e-16
## ACT_SAT_Math_Percentile  0.03818    0.03683   586.63226   1.037   0.3003
## AP_Calculus_ABPoor  0.06950    0.16071   586.66223   0.432   0.6656
## AP_Calculus_ABWell  0.17155    0.10134   586.45597   1.693   0.0910
## AP_Calculus_BCPoor -0.08935    0.14491   586.06038  -0.617   0.5377
## AP_Calculus_BCWell -0.11358    0.09660   586.18588  -1.176   0.2401
## SemesterSP       -0.43190    0.16617    1.61248  -2.599   0.1506
## SequenceHonours   -0.16480    0.20220    3.53088  -0.815   0.4664
##
## (Intercept)      .
## GenderF          .
## URM_StatusURM    *
## Class_StandingBFY
## First_Gen_StatusFirstGen .
## PreScores        ***
## ACT_SAT_Math_Percentile
## AP_Calculus_ABPoor
## AP_Calculus_ABWell .

```

```

## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## SemesterSP
## SequenceHonours
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##           R2m           R2c
## [1,] 0.3347294 0.3459109
## [1] 1517.854
##
## % Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
## % Date and time: Mon, Aug 17, 2020 - 3:16:48 PM
## \begin{table}[!htbp] \centering
##   \caption{}
##   \label{}
## \begin{tabular}{@{\extracolsep{5pt}}lcccccccc}
## \hline \hline
## & \multicolumn{9}{c}{\textit{Dependent variable:}} \\
## \cline{2-10}
## \hline & \multicolumn{9}{c}{PostScores} \\
## \hline & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) & (9) \\
## \hline
## Constant & 0.136 & 0.283 & 0.194 & 0.147 & 0.187 & 0.468^{**} & 0.160 & 0.080 & 0.445^{**} \\
## & (0.177) & (0.181) & (0.171) & (0.182) & (0.175) & (0.178) & (0.139) & (0.150) & (0.169) \\
## & & & & & & & & & \\
## GenderF & & $-0.269^{***}$ & & & & $-0.359^{***}$ & & $-0.097$ & $-0.089$ & $-0.090$ \\
## & & (0.079) & & & & (0.081) & & (0.073) & (0.073) & (0.073) \\
## & & & & & & & & & & \\
## URM\_StatusURM & & $-0.269^{**}$ & & & & $-0.349^{***}$ & & $-0.190^{*}$ & & $-0.164^{*}$ \\
## & & (0.090) & & & & (0.092) & & (0.080) & (0.083) & (0.083) \\
## & & & & & & & & & & \\
## Class\_StandingBFY & & & & $-0.163$ & & $-0.230$ & 0.077 & 0.108 & 0.087 \\
## & & & & (0.184) & & (0.180) & (0.158) & (0.161) & (0.162) \\
## & & & & & & & & & & \\
## First\_Gen\_StatusFirstGen & & & & & & $-0.356^{**}$ & & $-0.319^{**}$ & & $-0.203^{*}$ \\
## & & & & & & (0.117) & & (0.115) & (0.101) & (0.101) & (0.101) \\
## & & & & & & & & & & \\
## PreScores & & & & & & 0.501^{***} & & 0.493^{***} & & 0.493^{***} \\
## & & & & & & (0.036) & & (0.037) & (0.037) \\
## & & & & & & & & & & \\
## ACT\_SAT\_Math\_Percentile & & & & & & & & 0.037 & 0.038 \\
## & & & & & & & & (0.037) & (0.037) \\
## & & & & & & & & & & \\
## AP\_Calculus\_ABPoor & & & & & & & & 0.068 & 0.069 \\
## & & & & & & & & (0.161) & (0.161) \\
## & & & & & & & & & & \\
## AP\_Calculus\_ABWell & & & & & & & & 0.172 & 0.172 \\
## & & & & & & & & (0.101) & (0.101) \\
## & & & & & & & & & & \\
## AP\_Calculus\_BCPoor & & & & & & & & $-0.086$ & $-0.089$ \\
## & & & & & & & & (0.145) & (0.145) \\
## & & & & & & & & & & \\
## AP\_Calculus\_BCWell & & & & & & & & $-0.099$ & $-0.114$

```

```
## & & & & & & & (0.096) & (0.097) \\
## & & & & & & & \\
## SemesterSP & & & & & & & & & $-$0.432$^{**}$ \\
## & & & & & & & & (0.166) \\
## & & & & & & & \\
## SequenceHonours & & & & & & & & $-$0.165 \\
## & & & & & & & & (0.202) \\
## & & & & & & & \\
## \hline \\[-1.8ex]
## \hline
## \hline \\[-1.8ex]
## \textit{Note:} & \multicolumn{9}{r}{\textit{$^{*}$p$<$0.05; $^{**}$p$<$0.01; $^{***}$p$<$0.001}} \\
## \end{tabular}
## \end{table}
```

```
MBT.Coeffs <- df.MBT.fit5$Coeffs
```

```
png('Figures/DiagnosticPlots/MBT_ResidFitted.png', width = 363, height = 363)
plot(df.MBT.fit5$model, xlab = 'Fitted values', ylab = 'Residuals')
dev.off()
```

```
## pdf
## 2
```

```
png('Figures/DiagnosticPlots/MBT_qq.png', width = 363, height = 363)
qqmath(df.MBT.fit5$model)
dev.off()
```

```
## pdf
## 2
```

```
vif(df.MBT.fit5$model)
```

```
##
##          GVIF Df GVIF^(1/(2*Df))
## Gender          1.171209 1      1.082224
## URM_Status       1.169564 1      1.081464
## Class_Standing   1.093429 1      1.045671
## First_Gen_Status 1.027181 1      1.013499
## PreScores        1.204236 1      1.097377
## ACT_SAT_Math_Percentile 1.215942 1      1.102698
## AP_Calculus_AB    1.993610 2      1.188256
## AP_Calculus_BC    2.086955 2      1.201928
## Semester         1.124390 1      1.060373
## Sequence         1.094657 1      1.046259
```

PLIC regressions

```
df.PLIC <- Load.Clean.Data(assessment = 'PLIC')
df.PLIC.fit5 <- Do.Regressions(df.PLIC, assessment = 'PLIC')
```

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2109.8
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4683 -0.5776  0.0248  0.6637  3.2509
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.06128 0.2476
## Residual 0.96595 0.9828
## Number of obs: 747, groups: Class_ID, 9
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.03656 0.09745 6.79446 0.375 0.719
## R2m R2c
## [1,] 0 0.05965972
## [1] 2115.757
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Gender + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2111.4
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4226 -0.5913  0.0202  0.6559  3.1909
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.05358 0.2315
## Residual 0.96594 0.9828
## Number of obs: 747, groups: Class_ID, 9
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.08125 0.09870 8.49390 0.823 0.433
## GenderF -0.09948 0.07425 740.72367 -1.340 0.181
##
## Correlation of Fixed Effects:
## (Intr)
## GenderF -0.349
## R2m R2c
## [1,] 0.002419115 0.05484502
## [1] 2119.363
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ URM_Status + (1 | Class_ID)

```



```

## Data: dat
##
## REML criterion at convergence: 2112.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4769 -0.5741  0.0173  0.6548  3.2305
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.0603   0.2456
##   Residual              0.9667   0.9832
## Number of obs: 747, groups:  Class_ID, 9
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)    0.04813    0.09816   7.18526   0.490    0.639
## URM_StatusURM -0.06570    0.08962  741.57316  -0.733    0.464
##
## Correlation of Fixed Effects:
##              (Intr)
## URM_SttsURM -0.163
##              R2m      R2c
## [1,] 0.0006949313 0.05937464
## [1] 2120.207
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: PostScores ~ Class_Standing + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2111.9
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4757 -0.5808  0.0236  0.6625  3.2457
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.05682   0.2384
##   Residual              0.96763   0.9837
## Number of obs: 747, groups:  Class_ID, 9
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)    0.04594    0.09813   6.24181   0.468    0.656
## Class_StandingBFY -0.05023    0.12759  141.46377  -0.394    0.694
##
## Correlation of Fixed Effects:
##              (Intr)
## Clss_StnBFY -0.265
##              R2m      R2c
## [1,] 0.0003565665 0.05580282
## [1] 2119.895
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [

```

```
## lmerModLmerTest]
## Formula: PostScores ~ First_Gen_Status + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2105.8
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -4.5116 -0.5719 0.0324 0.6508 3.2214
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.05804 0.2409
## Residual 0.95926 0.9794
## Number of obs: 747, groups: Class_ID, 9
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.06605 0.09605 6.99125 0.688 0.5138
## First_Gen_StatusFirstGen -0.28814 0.11319 739.32460 -2.546 0.0111 *
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
## (Intr)
## Frst_Gn_SFG -0.123
## R2m R2c
## [1,] 0.008173715 0.06476212
## [1] 2113.822
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
## (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2111.6
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -4.4765 -0.5758 0.0320 0.6476 3.1192
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.04427 0.2104
## Residual 0.96134 0.9805
## Number of obs: 747, groups: Class_ID, 9
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.14365 0.09930 8.56493 1.447 0.1836
## GenderF -0.11885 0.07610 724.75802 -1.562 0.1188
## URM_StatusURM -0.08874 0.09211 741.84693 -0.963 0.3356
## Class_StandingBFY -0.04804 0.12510 100.00307 -0.384 0.7018
```

```

## First_Gen_StatusFirstGen -0.28242    0.11350 735.50314 -2.488    0.0131 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr) GendrF URM_SU C_SBFY
## GenderF      -0.390
## URM_SttsURM  -0.232  0.234
## Clss_StnBFY  -0.234 -0.021 -0.054
## Frst_Gn_SFG  -0.099 -0.013 -0.045 -0.036
##          R2m      R2c
## [1,] 0.0128588 0.05631931
## [1] 2125.58
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##   PreScores + (1 | Class_ID)
##   Data: dat
##
## REML criterion at convergence: 2043.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.8852 -0.5822  0.0540  0.6372  2.8180
##
## Random effects:
##   Groups   Name      Variance Std.Dev.
##   Class_ID (Intercept) 0.02658  0.1630
##   Residual              0.87457  0.9352
## Number of obs: 747, groups:  Class_ID, 9
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      0.11677    0.08502   9.08349   1.373   0.2026
## GenderF          -0.12458    0.07232  700.65858  -1.723   0.0854
## URM_StatusURM    -0.01736    0.08813  740.90506  -0.197   0.8439
## Class_StandingBFY -0.14093    0.11539   62.82620  -1.221   0.2265
## First_Gen_StatusFirstGen -0.22054    0.10846  734.71619  -2.033   0.0424
## PreScores         0.30702    0.03498  740.74727   8.777 <2e-16
##
## (Intercept)
## GenderF      .
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen *
## PreScores      ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr) GendrF URM_SU C_SBFY F_G_SF
## GenderF      -0.435
## URM_SttsURM  -0.264  0.231

```

```

## Clss_StnBFY -0.242 -0.031 -0.060
## Frst_Gn_SFG -0.114 -0.013 -0.039 -0.038
## PreScores -0.043 0.002 0.095 -0.062 0.066
## R2m R2c
## [1,] 0.107093 0.1334344
## [1] 2059.279
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
## PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
## (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2051.4
##
## Scaled residuals:
## Min 1Q Median 3Q Max
## -4.8445 -0.5698 0.0965 0.6372 2.8055
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.02403 0.1550
## Residual 0.87459 0.9352
## Number of obs: 747, groups: Class_ID, 9
##
## Fixed effects:
## Estimate Std. Error df t value Pr(>|t|)
## (Intercept) 0.18893 0.10638 23.31803 1.776 0.0888
## GenderF -0.14098 0.07280 686.74310 -1.936 0.0532
## URM_StatusURM -0.06312 0.09157 735.80834 -0.689 0.4909
## Class_StandingBFY -0.19081 0.11763 56.33193 -1.622 0.1104
## First_Gen_StatusFirstGen -0.23734 0.10893 730.39892 -2.179 0.0297
## PreScores 0.31311 0.03513 735.85111 8.913 <2e-16
## ACT_SAT_Math_Percentile -0.06459 0.03773 732.90563 -1.712 0.0873
## AP_Calculus_ABPoor 0.06894 0.21669 732.42967 0.318 0.7505
## AP_Calculus_ABWell -0.16228 0.12004 733.62068 -1.352 0.1768
## AP_Calculus_BCPoor 0.03559 0.19020 731.33112 0.187 0.8516
## AP_Calculus_BCWell 0.12023 0.11347 716.04112 1.060 0.2897
##
## (Intercept) .
## GenderF .
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen *
## PreScores ***
## ACT_SAT_Math_Percentile .
## AP_Calculus_ABPoor
## AP_Calculus_ABWell
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##

```

```

## Correlation of Fixed Effects:
##          (Intr) GendrF URM_SU C_SBFY F_G_SF PrScrs ACT_SA AP_C_ABP
## GenderF      -0.352
## URM_SttsURM  -0.302  0.242
## Clss_StnBFY  -0.235 -0.018  0.002
## Frst_Gn_SFG  -0.090 -0.003 -0.026 -0.031
## PreScores     0.009 -0.003  0.071 -0.077  0.063
## ACT_SAT_M_P  -0.037  0.114  0.215  0.164  0.078 -0.044
## AP_Clcl_ABP  -0.170  0.029 -0.016 -0.103  0.026  0.014  0.040
## AP_Clcl_ABW  -0.380  0.032  0.044 -0.028  0.036 -0.039  0.043  0.338
## AP_Clcl_BCP   0.002 -0.047  0.034  0.044 -0.038  0.020 -0.054 -0.369
## AP_Clcl_BCW  -0.058 -0.049  0.040  0.074 -0.059 -0.005 -0.180 -0.193
##          AP_C_ABW AP_C_BCP
## GenderF
## URM_SttsURM
## Clss_StnBFY
## Frst_Gn_SFG
## PreScores
## ACT_SAT_M_P
## AP_Clcl_ABP
## AP_Clcl_ABW
## AP_Clcl_BCP -0.347
## AP_Clcl_BCW -0.720    0.388
##          R2m      R2c
## [1,] 0.1138736 0.1375737
## [1] 2077.384
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status +
##      PreScores + ACT_SAT_Math_Percentile + AP_Calculus_AB + AP_Calculus_BC +
##      Semester + Sequence + Course_Content + (1 | Class_ID)
## Data: dat
##
## REML criterion at convergence: 2050.5
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -4.8192 -0.5716  0.0826  0.6608  2.8587
##
## Random effects:
## Groups Name Variance Std.Dev.
## Class_ID (Intercept) 0.01233 0.1110
## Residual 0.87311 0.9344
## Number of obs: 747, groups: Class_ID, 9
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)    0.08937    0.13737 12.53415   0.651  0.5271
## GenderF        -0.11222    0.07383 732.69870  -1.520  0.1289
## URM_StatusURM  -0.04951    0.09165 732.97129  -0.540  0.5892
## Class_StandingBFY -0.05129    0.14051 731.25961  -0.365  0.7152
## First_Gen_StatusFirstGen -0.23637    0.10889 731.33842  -2.171  0.0303
## PreScores       0.30589    0.03522 731.91321   8.686 <2e-16

```

```

## ACT_SAT_Math_Percentile    -0.06045    0.03772  732.83667   -1.603    0.1094
## AP_Calculus_ABPoor        0.06332    0.21659  732.28985    0.292    0.7701
## AP_Calculus_ABWell       -0.14491    0.12012  731.62410   -1.206    0.2280
## AP_Calculus_BCPoor        0.05510    0.19023  731.18319    0.290    0.7722
## AP_Calculus_BCWell        0.11268    0.11453  730.66932    0.984    0.3255
## SemesterSP                0.03169    0.13207    4.50844    0.240    0.8209
## SequenceHonours           0.25364    0.13454    6.64599    1.885    0.1036
## Course_ContentEM          -0.32085    0.21118    8.69927   -1.519    0.1642
##
## (Intercept)
## GenderF
## URM_StatusURM
## Class_StandingBFY
## First_Gen_StatusFirstGen *
## PreScores                  ***
## ACT_SAT_Math_Percentile
## AP_Calculus_ABPoor
## AP_Calculus_ABWell
## AP_Calculus_BCPoor
## AP_Calculus_BCWell
## SemesterSP
## SequenceHonours
## Course_ContentEM
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##              R2m      R2c
## [1,] 0.1373909 0.1494016
## [1] 2082.507
##
## % Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
## % Date and time: Mon, Aug 17, 2020 - 3:16:55 PM
## \begin{table}[!htbp] \centering
##   \caption{}
##   \label{}
##   \begin{tabular}{@{\extracolsep{5pt}}lcccccccc}
##     \hline
##     \hline \hline
##     & \multicolumn{9}{c}{\textit{Dependent variable:}} & \hline
##     \hline
##     \hline & \multicolumn{9}{c}{PostScores} & \hline
##     \hline & (1) & (2) & (3) & (4) & (5) & (6) & (7) & (8) & (9) & \hline
##     \hline
##     Constant & 0.037 & 0.081 & 0.048 & 0.046 & 0.066 & 0.144 & 0.117 & 0.189 & 0.089 & \hline
##     & (0.097) & (0.099) & (0.098) & (0.098) & (0.096) & (0.099) & (0.085) & (0.106) & (0.137) & \hline
##     & & & & & & & & & & \hline
##     GenderF & & $-0.099 & & & & $-0.119 & $-0.125 & $-0.141 & $-0.112 & \hline
##     & & (0.074) & & & & (0.076) & (0.072) & (0.073) & (0.074) & \hline
##     & & & & & & & & & & \hline
##     URM\_StatusURM & & & $-0.066 & & & $-0.089 & $-0.017 & $-0.063 & $-0.050 & \hline
##     & & & (0.090) & & & (0.092) & (0.088) & (0.092) & (0.092) & \hline
##     & & & & & & & & & & \hline
##     Class\_StandingBFY & & & & $-0.050 & & & $-0.048 & $-0.141 & $-0.191 & $-0.051 & \hline
##     & & & & (0.128) & & & (0.125) & (0.115) & (0.118) & (0.141) & \hline
##     & & & & & & & & & & \hline

```



```
vif(df.PLIC.fit5$model)
```

```
##              GVIF Df  GVIF^(1/(2*Df))
## Gender          1.119176  1      1.057911
## URM_Status      1.164734  1      1.079228
## Class_Standing  1.728527  1      1.314734
## First_Gen_Status 1.018577  1      1.009246
## PreScores       1.038316  1      1.018978
## ACT_SAT_Math_Percentile 1.192992  1      1.092242
## AP_Calculus_AB  2.539296  2      1.262346
## AP_Calculus_BC  2.706066  2      1.282580
## Semester        1.323177  1      1.150294
## Sequence        1.223388  1      1.106069
## Course_Content  1.734730  1      1.317091
```

Plot fixed effects across models and asesments

```
png("Figures/FixedEffects.png", units = "in", width = 6, height = 5, res = 300)

# combine all assessment data.frames of fixed effects
Coefs <- rbind(PLIC.Coefs %>% mutate(Assessment = 'PLIC'),
              ECLASS.Coefs %>% mutate(Assessment = 'E-CLASS'),
              MBT.Coefs %>% mutate(Assessment = 'MBT'),
              CSEM.Coefs %>% mutate(Assessment = 'CSEM')) %>%
  filter(term == 'GenderF' | term == 'URM_StatusURM' | term == 'Class_StandingBFY' |
         term == 'First_Gen_StatusFirstGen') %>% # only want demographic terms
  mutate(Model = as.character(Model),
         Assessment = factor(Assessment, levels = c('CSEM', 'E-CLASS', 'MBT', 'PLIC')))

ggplot(Coefs, aes(x = Model, y = estimate, group = term, color = term, shape = term)) +
  geom_point(size = 3) +
  geom_errorbar(aes(ymin = (estimate - std.error), ymax = (estimate + std.error)),
               width = 0.15, size = 1) +
  geom_line(size = 1) +
  geom_hline(data = Coefs, aes(yintercept = 0), linetype = 'dashed') +
  facet_wrap(~ Assessment, scales = "free") + # make 2 x 2 grid of plots
  theme_classic(base_size = 10) +
  scale_color_manual(breaks = c('GenderF', 'URM_StatusURM', 'Class_StandingBFY',
                                'First_Gen_StatusFirstGen'),
                    labels = c('Gender', 'URM status', 'Class standing',
                                'First-generation status'),
                    values = c('#e69f00', '#009e74', '#0071b2', '#cc79a7')) +
  scale_shape_manual(breaks = c('GenderF', 'URM_StatusURM', 'Class_StandingBFY',
                                'First_Gen_StatusFirstGen'),
                    labels = c('Gender', 'URM status', 'Class standing',
                                'First-generation status'),
                    values = c(15, 16, 17, 18)) +
  theme(legend.title = element_blank(),
        legend.position = 'top',
        legend.text = element_text(size = 10)) +
```



```
ylab('Coefficient')
dev.off()
```

```
## pdf
## 2
```

Monte Carlo power analysis

```
Do.Simulated.Power <- function(model, var, fixed.eff, eff = -0.2, nsim = 100){
  # simulate model with coefficient for one demographic variable set equal to -0.2
  # simulate nsim number of times to determine fraction of times statistically significant
  # result at  $\alpha = 0.05$  is detected --- power
  fixef(model)[fixed.eff] <- eff
  pow <- powerSim(model, test = fixed(var), progress = FALSE, nsim = nsim)
  return(pow)
}

# only perform power analysis for non-statistically significant results in original fits
lapply(list(c('Gender', 'GenderF'), c('URM_Status', 'URM_StatusURM'), c('Class_Standing', 'Class_Standi
  Do.Simulated.Power(model = df.PLIC.fit5$model, var = x[1], fixed.eff = x[2])
})
```

```
## [[1]]
## Power for predictor 'Gender', (95% confidence interval):
##      78.00% (68.61, 85.67)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (2 warnings, 0 errors)
## alpha = 0.05, nrow = 747
##
## Time elapsed: 0 h 0 m 25 s
##
## [[2]]
## Power for predictor 'URM_Status', (95% confidence interval):
##      62.00% (51.75, 71.52)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (6 warnings, 0 errors)
## alpha = 0.05, nrow = 747
##
## Time elapsed: 0 h 0 m 24 s
##
## [[3]]
## Power for predictor 'Class_Standing', (95% confidence interval):
##      34.00% (24.82, 44.15)
##
## Test: Likelihood ratio
##
```

```

## Based on 100 simulations, (3 warnings, 0 errors)
## alpha = 0.05, nrow = 747
##
## Time elapsed: 0 h 0 m 25 s

lapply(list(c('Gender', 'GenderF'), c('URM_Status', 'URM_StatusURM'), c('Class_Standing', 'Class_StandingURM')),
  Do.Simulated.Power(model = df.ECLASS.fit5$model, var = x[1], fixed.eff = x[2])
})

## [[1]]
## Power for predictor 'Gender', (95% confidence interval):
##      88.00% (79.98, 93.64)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (1 warning, 0 errors)
## alpha = 0.05, nrow = 683
##
## Time elapsed: 0 h 0 m 26 s
##
## [[2]]
## Power for predictor 'URM_Status', (95% confidence interval):
##      72.00% (62.13, 80.52)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (8 warnings, 0 errors)
## alpha = 0.05, nrow = 683
##
## Time elapsed: 0 h 0 m 24 s
##
## [[3]]
## Power for predictor 'Class_Standing', (95% confidence interval):
##      51.00% (40.80, 61.14)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (2 warnings, 0 errors)
## alpha = 0.05, nrow = 683
##
## Time elapsed: 0 h 0 m 25 s
##
## [[4]]
## Power for predictor 'First_Gen_Status', (95% confidence interval):
##      47.00% (36.94, 57.24)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (5 warnings, 0 errors)
## alpha = 0.05, nrow = 683
##
## Time elapsed: 0 h 0 m 25 s

```

```
lapply(list(c('Gender', 'GenderF'), c('Class_Standing', 'Class_StandingBFY'), c('First_Gen_Status', 'Fi
  Do.Simulated.Power(model = df.MBT.fit5$model, var = x[1], fixed.eff = x[2])
})
```

```
## [[1]]
## Power for predictor 'Gender', (95% confidence interval):
##      81.00% (71.93, 88.16)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (4 warnings, 0 errors)
## alpha = 0.05, nrow = 600
##
## Time elapsed: 0 h 0 m 23 s
##
## [[2]]
## Power for predictor 'Class_Standing', (95% confidence interval):
##      22.00% (14.33, 31.39)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (3 warnings, 0 errors)
## alpha = 0.05, nrow = 600
##
## Time elapsed: 0 h 0 m 24 s
##
## [[3]]
## Power for predictor 'First_Gen_Status', (95% confidence interval):
##      53.00% (42.76, 63.06)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (2 warnings, 0 errors)
## alpha = 0.05, nrow = 600
##
## Time elapsed: 0 h 0 m 22 s
```

```
lapply(list(c('URM_Status', 'URM_StatusURM'), c('Class_Standing', 'Class_StandingBFY'), c('First_Gen_Sta
  Do.Simulated.Power(model = df.CSEM.fit5$model, var = x[1], fixed.eff = x[2])
})
```

```
## [[1]]
## Power for predictor 'URM_Status', (95% confidence interval):
##      57.00% (46.71, 66.86)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (5 warnings, 0 errors)
## alpha = 0.05, nrow = 587
##
## Time elapsed: 0 h 0 m 25 s
##
## [[2]]
```

```
## Power for predictor 'Class_Standing', (95% confidence interval):
##      31.00% (22.13, 41.03)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (5 warnings, 0 errors)
## alpha = 0.05, nrow = 587
##
## Time elapsed: 0 h 0 m 25 s
##
## [[3]]
## Power for predictor 'First_Gen_Status', (95% confidence interval):
##      46.00% (35.98, 56.26)
##
## Test: Likelihood ratio
##
## Based on 100 simulations, (9 warnings, 0 errors)
## alpha = 0.05, nrow = 587
##
## Time elapsed: 0 h 0 m 22 s
```

Analysis of missing data

Comparison of overall averages in different datasets

```
df.master <- fread('OVB_Master.csv')

### Matched ###
df.master[!is.na(PreScores) & !is.na(PostScores), .(N,
  avg.GPA = mean(GPA),
  stderror.GPA = sd(GPA)/sqrt(.N),
  avg.pre = mean(PreScores),
  sderror.pre = sd(PreScores)/sqrt(.N),
  avg.post = mean(PostScores),
  sderror.post = sd(PostScores)/sqrt(.N)), Assessment]
```

```
##      Assessment    N  avg.GPA  stderror.GPA  avg.pre  sderror.pre  avg.post
## 1:      CSEM  587  3.499308    0.01715578  15.80579    0.25896186  21.29472
## 2:     ECLASS  683  3.460325    0.01738751  17.18009    0.25414748  14.90630
## 3:      MBT   600  3.328220    0.02031612  13.82333    0.17310283  16.51667
## 4:     PLIC   747  3.390216    0.01772733   5.30448    0.03863135   5.75146
##      sderror.post
## 1:    0.27710818
## 2:    0.32188455
## 3:    0.17567608
## 4:    0.04043072
```

```
### Valid Pre ONLY ###
df.master[!is.na(PreScores) & is.na(PostScores), .(N.pre = .N,
  avg.GPA = mean(GPA),
```

```
stderror.GPA = sd(GPA)/sqrt(.N),
avg.pre = mean(PreScores),
sderror.pre = sd(PreScores)/sqrt(.N)), Assessment]
```

```
##      Assessment N.pre  avg.GPA stderror.GPA  avg.pre sderror.pre
## 1:      CSEM    279 3.226129  0.03135033 13.878136  0.3071200
## 2:      ECLASS   287 3.261157  0.03092807 16.282230  0.3746971
## 3:       MBT    112 3.134839  0.04861887 12.348214  0.4317495
## 4:      PLIC     59 3.544814  0.04614179  5.266169  0.1513422
```

```
### Valid Post ONLY ###
```

```
df.master[is.na(PreScores) & !is.na(PostScores), .(N.post = .N,
                                                    avg.GPA = mean(GPA),
                                                    stderror.GPA = sd(GPA)/sqrt(.N),
                                                    avg.post = mean(PostScores),
                                                    sderror.post = sd(PostScores)/sqrt(.N)), Assessment]
```

```
##      Assessment N.post  avg.GPA stderror.GPA  avg.post sderror.post
## 1:      CSEM    126 3.325944  0.03976368 17.182540  0.6380925
## 2:      ECLASS    52 3.341038  0.10022606 14.211538  1.1030386
## 3:       MBT     50 3.195680  0.06198340 13.340000  0.7712222
## 4:      PLIC    160 3.351281  0.04086785  5.298517  0.1071467
```

```
### No Survey ###
```

```
df.master[is.na(PreScores) & is.na(PostScores), .(N.no = .N,
                                                    avg.GPA = mean(GPA),
                                                    stderror.GPA = sd(GPA)/sqrt(.N)), Assessment]
```

```
##      Assessment N.no  avg.GPA stderror.GPA
## 1:      CSEM    515 3.209596  0.02267177
## 2:      ECLASS   148 3.279730  0.04464013
## 3:       MBT    258 3.307264  0.03052271
## 4:      PLIC    959 3.280111  0.01620232
```

Multiple imputation of missing data

```
Impute.Analyze <- function(assessment){
  # impute data using multiple imputation and pool results using Rubin's rules
  df.imp <- Load.Clean.Data(assessment = assessment, impute = TRUE)
  if(assessment == 'ECLASS' | assessment == 'PLIC'){
    model <- 'PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status + PreScores + ACT_SA
  } else {
    model <- 'PostScores ~ Gender + URM_Status + Class_Standing + First_Gen_Status + PreScores + ACT_SA
  }
  fit <- with(df.imp, lme4::lmer(formula(model))) # perform fit on all imputed datasets
  print(summary(pool(fit))) # and pool results for coefficients and uncertainties

  # we do the pooling for fit statistics manually, but still follow Rubin's rules
  df.complete <- mice::complete(df.imp, "long", include = FALSE)
```

```

R2M.L <- c()
R2C.L <- c()
AIC.L <- c()
m <- max(df.complete$.imp)
for(i in 1:m){
  model.imputed <- lme4::lmer(formula(model), data = df.complete[which(df.complete$.imp == i),])

  R2 <- r.squaredGLMM(model.imputed)
  R2M.L[i] <- R2[1, 'R2m']
  R2C.L[i] <- R2[1, 'R2c']
  AIC.L[i] <- AIC(model.imputed)
}
print(mean(R2M.L))
print(sd(R2M.L))
print(mean(R2C.L))
print(sd(R2C.L))
print(mean(AIC.L))
print(sd(AIC.L))
}

Impute.Analayze('MBT')

```

```

## [1] "% of students without matched data:"
## [1] 41
##
##              estimate  std.error  statistic      df
## (Intercept)    0.309435099  0.11814809   2.61904452  223.15420
## GenderF        -0.097878102  0.06992767  -1.39970498  203.87303
## URM_StatusURM  -0.170219404  0.07631108  -2.23059887  265.75373
## Class_StandingBFY -0.008933773  0.15687909  -0.05694687  116.86752
## First_Gen_StatusFirstGen -0.137398357  0.10020925  -1.37111454  149.06208
## PreScores      0.506442396  0.03484174  14.53550688  211.08723
## ACT_SAT_Math_Percentile 0.003621602  0.04346034   0.08333120   91.02785
## AP_Calculus_ABPoor 0.044288781  0.14694018   0.30140689  338.09447
## AP_Calculus_ABWell 0.217968871  0.09851137   2.21262655  230.69310
## AP_Calculus_BCPoor -0.111600410  0.14066094  -0.79340012  267.63660
## AP_Calculus_BCWell -0.124454581  0.09187970  -1.35453832  276.54836
## SemesterSP     -0.350167967  0.10016091  -3.49605417  230.57018
## SequenceHonours -0.094574640  0.15863040  -0.59619492  925.15668
##
##              p.value
## (Intercept)    0.0094221785
## GenderF        0.1631214718
## URM_StatusURM  0.0265426697
## Class_StandingBFY 0.9546847663
## First_Gen_StatusFirstGen 0.1723999672
## PreScores      0.0000000000
## ACT_SAT_Math_Percentile 0.9337711723
## AP_Calculus_ABPoor 0.7632895368
## AP_Calculus_ABWell 0.0279034676
## AP_Calculus_BCPoor 0.4282475657
## AP_Calculus_BCWell 0.1766703135
## SemesterSP     0.0005662526
## SequenceHonours 0.5511908545
## [1] 0.3482767

```

```
## [1] 0.01838996
## [1] 0.3498074
## [1] 0.01871913
## [1] 2542.703
## [1] 37.25904
```

```
Impute.Analayze('CSEM')
```

```
## [1] "% of students without matched data:"
## [1] 61
##
##              estimate  std.error  statistic      df
## (Intercept)    0.168658355  0.12680555   1.33005494  222.89028
## GenderF        -0.184771001  0.06550873  -2.82055518  160.06845
## URM_StatusURM  -0.032658706  0.08425694  -0.38760848  138.12946
## Class_StandingBFY -0.278282452  0.09947400  -2.79753949  214.36291
## First_Gen_StatusFirstGen 0.048996011  0.09804528   0.49972841  157.23936
## PreScores      0.508033517  0.04396815  11.55457975  115.75862
## ACT_SAT_Math_Percentile 0.035288942  0.04544725   0.77648132   82.14825
## AP_Calculus_ABPoor -0.401689103  0.18919632  -2.12313377  146.85464
## AP_Calculus_ABWell 0.064609273  0.11297907   0.57186939  135.29038
## AP_Calculus_BCPoor -0.103080480  0.18910283  -0.54510280  124.20088
## AP_Calculus_BCWell 0.045515414  0.09481339   0.48005260  161.99687
## SemesterSP     -0.045515756  0.09385921  -0.48493650  189.92798
## SequenceHonours 0.008210482  0.10114817   0.08117282  445.15001
##
##              p.value
## (Intercept)    0.184859552
## GenderF        0.005400983
## URM_StatusURM  0.698902418
## Class_StandingBFY 0.005618093
## First_Gen_StatusFirstGen 0.617964899
## PreScores      0.000000000
## ACT_SAT_Math_Percentile 0.439694870
## AP_Calculus_ABPoor 0.035419302
## AP_Calculus_ABWell 0.568359413
## AP_Calculus_BCPoor 0.586660345
## AP_Calculus_BCWell 0.631837544
## SemesterSP     0.628280227
## SequenceHonours 0.935340996
## [1] 0.3653969
## [1] 0.02143981
## [1] 0.3658829
## [1] 0.02152601
## [1] 3683.862
## [1] 60.37692
```

```
Impute.Analayze('ECLASS')
```

```
## [1] "% of students without matched data:"
## [1] 42
##
##              estimate  std.error  statistic      df
## (Intercept)    -0.10855988  0.14652799  -0.74088151  127.20097
## GenderF        -0.06177229  0.06578749  -0.93896711  145.14164
## URM_StatusURM  -0.07423677  0.07533533  -0.98541764  255.89694
```

```
## Class_StandingBFY      -0.11259858 0.11589095 -0.97159086 101.81103
## First_Gen_StatusFirstGen -0.05074426 0.11573715 -0.43844396 101.54368
## PreScores              0.54921583 0.02620974 20.95464944 418.89813
## ACT_SAT_Math_Percentile 0.01101045 0.04051908 0.27173490 82.21541
## AP_Calculus_ABPoor     -0.08980819 0.22346008 -0.40189815 102.77129
## AP_Calculus_ABWell     -0.01005444 0.12563161 -0.08003113 99.98064
## AP_Calculus_BCPoor     -0.12916806 0.20104151 -0.64249447 145.51254
## AP_Calculus_BCWell     -0.06100980 0.10560158 -0.57773565 139.13445
## SemesterSP             0.20283492 0.10835846 1.87188824 156.80867
## SequenceHonours        0.17651812 0.09907004 1.78175069 229.21744
## Course_ContentMechanics 0.30462887 0.12006636 2.53717089 157.61824
##                          p.value
## (Intercept)            0.46013079
## GenderF                0.34930759
## URM_StatusURM          0.32534976
## Class_StandingBFY      0.33355679
## First_Gen_StatusFirstGen 0.66199586
## PreScores              0.00000000
## ACT_SAT_Math_Percentile 0.78650705
## AP_Calculus_ABPoor     0.68859357
## AP_Calculus_ABWell     0.93637247
## AP_Calculus_BCPoor     0.52156319
## AP_Calculus_BCWell     0.56437641
## SemesterSP             0.06308444
## SequenceHonours        0.07611379
## Course_ContentMechanics 0.01214661
## [1] 0.4141483
## [1] 0.01125626
## [1] 0.4159421
## [1] 0.01052998
## [1] 2785.109
## [1] 46.13408
```

```
Impute.Analyze('PLIC')
```

```
## [1] "% of students without matched data:"
## [1] 61
##               estimate std.error statistic    df
## (Intercept)   -0.137686044 0.17509238 -0.7863623 317.1929
## GenderF       -0.091427264 0.06516914 -1.4029227 182.7833
## URM_StatusURM -0.049847969 0.08387005 -0.5943477 155.9389
## Class_StandingBFY -0.173372620 0.12294755 -1.4101348 214.7410
## First_Gen_StatusFirstGen -0.184239522 0.09590547 -1.9210533 174.3303
## PreScores      0.276134094 0.03630225 7.6065287 126.8941
## ACT_SAT_Math_Percentile -0.067779132 0.04000824 -1.6941294 116.0626
## AP_Calculus_ABPoor 0.084220120 0.20896833 0.4030281 113.9095
## AP_Calculus_ABWell -0.057387363 0.10895294 -0.5267170 159.7748
## AP_Calculus_BCPoor 0.113310276 0.16870938 0.6716300 154.3523
## AP_Calculus_BCWell 0.028528704 0.09163719 0.3113224 226.7292
## SemesterSP      0.005603959 0.11598197 0.0483175 377.2094
## SequenceHonours 0.156757822 0.11980196 1.3084746 340.9903
## Course_ContentMechanics 0.278747982 0.15595336 1.7873804 433.7078
##               p.value
## (Intercept)   4.322423e-01
```



```
## GenderF 1.623362e-01
## URM_StatusURM 5.531409e-01
## Class_StandingBFY 1.599467e-01
## First_Gen_StatusFirstGen 5.635662e-02
## PreScores 5.532463e-12
## ACT_SAT_Math_Percentile 9.292261e-02
## AP_Calculus_ABPoor 6.876830e-01
## AP_Calculus_ABWell 5.991206e-01
## AP_Calculus_BCPoor 5.028233e-01
## AP_Calculus_BCWell 7.558416e-01
## SemesterSP 9.614888e-01
## SequenceHonours 1.915936e-01
## Course_ContentMechanics 7.457418e-02
## [1] 0.1276323
## [1] 0.01913691
## [1] 0.1354297
## [1] 0.01970902
## [1] 5307.013
## [1] 70.56374
```

Compare linear mixed models with small number of level-2 samples to OLS

```
# used the MBT since that dataset had the fewest number of level-2 samples
df.MBT.fit5.lm <- lm(PostScores ~ Gender + URM_Status + Class_Standing +
                     First_Gen_Status + PreScores + ACT_SAT_Math_Percentile +
                     AP_Calculus_AB + AP_Calculus_BC + Semester + Sequence + Class_ID,
                     data = df.MBT)

summary(df.MBT.fit5.lm)
```

```
##
## Call:
## lm(formula = PostScores ~ Gender + URM_Status + Class_Standing +
##     First_Gen_Status + PreScores + ACT_SAT_Math_Percentile +
##     AP_Calculus_AB + AP_Calculus_BC + Semester + Sequence + Class_ID,
##     data = df.MBT)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.06656 -0.45391  0.04756  0.54259  2.42540
##
## Coefficients: (2 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.44553    0.13081   3.406 0.000704 ***
## GenderF        -0.09072    0.07291  -1.244 0.213895
## URM_StatusURM  -0.16559    0.08285  -1.999 0.046107 *
## Class_StandingBFY  0.08991    0.16193   0.555 0.578931
## First_Gen_StatusFirstGen -0.19287    0.10114  -1.907 0.057006 .
## PreScores       0.49260    0.03727  13.218 < 2e-16 ***
## ACT_SAT_Math_Percentile  0.03913    0.03684   1.062 0.288574
```

```
## AP_Calculus_ABPoor      0.06520      0.16077      0.406 0.685197
## AP_Calculus_ABWell      0.16941      0.10137      1.671 0.095210 .
## AP_Calculus_BCPoor     -0.08830      0.14491     -0.609 0.542519
## AP_Calculus_BCWell     -0.11233      0.09660     -1.163 0.245375
## SemesterSP             -0.51124      0.10567     -4.838 1.68e-06 ***
## SequenceHonours        -0.08550      0.15631     -0.547 0.584589
## Class_ID2018SP-1112      0.17014      0.07878      2.160 0.031196 *
## Class_ID2019SP-1112      NA          NA          NA      NA
## Class_ID2019SP-1116      NA          NA          NA      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8156 on 586 degrees of freedom
## Multiple R-squared:  0.3493, Adjusted R-squared:  0.3348
## F-statistic: 24.19 on 13 and 586 DF,  p-value: < 2.2e-16
```

```
AIC(df.MBT.fit5.lm)
```

```
## [1] 1473.933
```

```
stargazer(df.MBT.fit5$model, df.MBT.fit5.lm, star.cutoffs = c(0.05, 0.01, 0.001),
  intercept.bottom = FALSE, out = paste('MBT_LMcomp.tex'), intercept.top = TRUE,
  omit.stat = 'all')
```

```
##
## % Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
## % Date and time: Mon, Aug 17, 2020 - 3:27:12 PM
## \begin{table}[!htbp] \centering
##   \caption{}
##   \label{}
##   \begin{tabular}{@{\extracolsep{5pt}}lcc}
##     \hline
##     \hline \hline \hline
##     & \multicolumn{2}{c}{\textit{Dependent variable:}} & \\
##     \cline{2-3}
##     \hline \hline & \multicolumn{2}{c}{PostScores} & \\
##     \hline \hline & \textit{linear} & \textit{OLS} & \\
##     & \textit{mixed-effects} & \textit{} & \\
##     \hline \hline & (1) & (2) & \\
##     \hline \hline
##     Constant & 0.445$^{**}$ & 0.446$^{***}$ & \\
##     & (0.169) & (0.131) & \\
##     & & & \\
##     GenderF & $-$0.090 & $-$0.091 & \\
##     & (0.073) & (0.073) & \\
##     & & & \\
##     URM\_StatusURM & $-$0.167$^{*}$ & $-$0.166$^{*}$ & \\
##     & (0.083) & (0.083) & \\
##     & & & \\
##     Class\_StandingBFY & 0.087 & 0.090 & \\
##     & (0.162) & (0.162) & \\
##     & & & \\
##     First\_Gen\_StatusFirstGen & $-$0.193 & $-$0.193 & \end{table}
```

```

## & (0.101) & (0.101) \\
## & & \\
## PreScores & 0.493$^{***}$ & 0.493$^{***}$ \\
## & (0.037) & (0.037) \\
## & & \\
## ACT\_SAT\_Math\_Percentile & 0.038 & 0.039 \\
## & (0.037) & (0.037) \\
## & & \\
## AP\_Calculus\_ABPoor & 0.069 & 0.065 \\
## & (0.161) & (0.161) \\
## & & \\
## AP\_Calculus\_ABWell & 0.172 & 0.169 \\
## & (0.101) & (0.101) \\
## & & \\
## AP\_Calculus\_BCPoor & $-$0.089 & $-$0.088 \\
## & (0.145) & (0.145) \\
## & & \\
## AP\_Calculus\_BCWell & $-$0.114 & $-$0.112 \\
## & (0.097) & (0.097) \\
## & & \\
## SemesterSP & $-$0.432$^{**}$ & $-$0.511$^{***}$ \\
## & (0.166) & (0.106) \\
## & & \\
## SequenceHonours & $-$0.165 & $-$0.086 \\
## & (0.202) & (0.156) \\
## & & \\
## Class\_ID2018SP-1112 & & 0.170$^{*}$ \\
## & & (0.079) \\
## & & \\
## Class\_ID2019SP-1112 & & \\
## & & \\
## & & \\
## Class\_ID2019SP-1116 & & \\
## & & \\
## & & \\
## \hline \\[-1.8ex]
## \hline
## \hline \\[-1.8ex]
## \textit{Note:} & \multicolumn{2}{r}{ $^{*}$p$<$0.05; $^{**}$p$<$0.01; $^{***}$p$<$0.001} \\
## \end{tabular}
## \end{table}

```