Data File Management: The following SAS commands prepare the data set for the analyses.

Import the .csv file into SAS

```
*import the data;
proc import out=school1
             datafile= "C:\schooldata.csv"
                    dbms=csv replace;
                    getnames=yes;
                    datarow=2;
run;
```

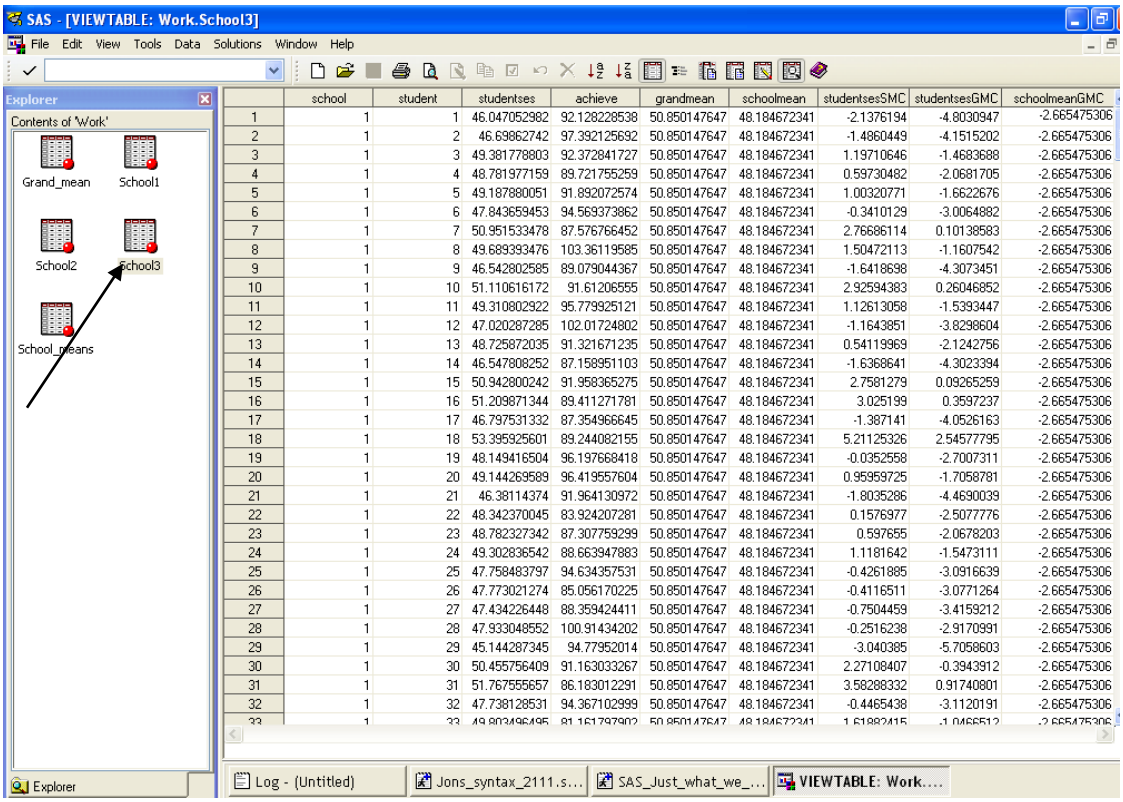
Data File Management steps that merge in grandmean, school mean, create descriptives and computes centered vars.

```
*get school mean SES - for group mean centering (more on this later);
*first sort the data by school (SAS requirement);
proc sort data=school1;
by school;
run;

*second get the mean studentSES for each school;
*output these to a new SAS data set called school_means;
proc means data=school1;
by school;
ods html file='C:\schmeans.xls'
style=minimal;
output out=school_means mean(studentses)=schoolmean;
run;
ods html close;

*third - open the school means data set and keep only the relevant variables;
data school_means (keep=school schoolmean);
set school_means;
run;

proc means data=school1;
var studentses;
output out=grand_mean mean(studentses)=grandmean;
run;

data grand_mean (keep = grandmean mergevar);
set grand mean;
mergevar=1;
run;

*to add grand_mean to everyone;
data school1;
set school1;
mergevar=1;
run;


data school2 (drop=mergevar);
merge school1 grand_mean;
by mergevar;
run;


*fourth - merge the school_means data set with the whole data set and subtract
* the school mean from each student's SES, creating a cluster mean
*centered variable;
data school3 (keep=school student achieve studentses schoolmean schoolmeanGMC studentsesSMC
studentsesGMC grandmean);
merge school2 school_means;
```

Sends output directly to Excel.

```
by school;
studentsesSMC=studentses-schoolmean;
studentsesGMC=studentses-grandmean;
schoolmeanGMC=schoolmean-grandmean;
run;
```

Working School3 data under EXPLORE



	school	student	studentses	achieve	grandmean	schoolmean	studentsesSMC	studentsesGMC	schoolmeanGMC
1	1	1	46.047052982	92.128228538	50.850147647	48.184672341	-2.1376194	-4.8030947	-2.665475306
2	1	2	46.69862742	97.392125692	50.850147647	48.184672341	-1.4860449	-4.1515202	-2.665475306
3	1	3	49.381778803	92.372841727	50.850147647	48.184672341	1.19710646	-1.4683688	-2.665475306
4	1	4	48.781977159	89.721755259	50.850147647	48.184672341	0.59730482	-2.0681705	-2.665475306
5	1	5	49.187880051	91.892072574	50.850147647	48.184672341	1.00320771	-1.6622676	-2.665475306
6	1	6	47.843659453	94.569373862	50.850147647	48.184672341	-0.3410129	-3.0064882	-2.665475306
7	1	7	50.951533478	87.576766452	50.850147647	48.184672341	2.76686114	0.10138583	-2.665475306
8	1	8	49.689393476	103.36119585	50.850147647	48.184672341	1.50472113	-1.1607542	-2.665475306
9	1	9	46.542802585	89.079044367	50.850147647	48.184672341	-1.6418698	-4.3073451	-2.665475306
10	1	10	51.110616172	91.61206555	50.850147647	48.184672341	2.92594383	0.26046852	-2.665475306
11	1	11	49.310802922	95.779925121	50.850147647	48.184672341	1.12613058	-1.5393447	-2.665475306
12	1	12	47.020287285	102.01724802	50.850147647	48.184672341	-1.1643851	-3.8298604	-2.665475306
13	1	13	48.725872035	91.321671235	50.850147647	48.184672341	0.54119969	-2.1242756	-2.665475306
14	1	14	46.547808252	87.158951103	50.850147647	48.184672341	-1.6368641	-4.3023394	-2.665475306
15	1	15	50.942800242	91.958365275	50.850147647	48.184672341	2.7581279	0.09265259	-2.665475306
16	1	16	51.209871344	89.411271781	50.850147647	48.184672341	3.025199	0.3597237	-2.665475306
17	1	17	46.797531332	87.354966645	50.850147647	48.184672341	-1.387141	-4.0526163	-2.665475306
18	1	18	53.395925601	89.244082155	50.850147647	48.184672341	5.21125326	2.54577795	-2.665475306
19	1	19	48.149416504	96.197668418	50.850147647	48.184672341	-0.0352558	-2.7007311	-2.665475306
20	1	20	49.144269589	96.419557604	50.850147647	48.184672341	0.95959725	-1.7058781	-2.665475306
21	1	21	46.38114374	91.964130972	50.850147647	48.184672341	-1.8035286	-4.4690039	-2.665475306
22	1	22	48.342370045	83.924207281	50.850147647	48.184672341	0.1576977	-2.5077776	-2.665475306
23	1	23	48.782327342	87.307759299	50.850147647	48.184672341	0.597655	-2.0678203	-2.665475306
24	1	24	49.302836542	88.663947883	50.850147647	48.184672341	1.1181642	-1.5473111	-2.665475306
25	1	25	47.758483797	94.634357531	50.850147647	48.184672341	-0.4261885	-3.0916639	-2.665475306
26	1	26	47.773021274	85.056170225	50.850147647	48.184672341	-0.4116511	-3.0771264	-2.665475306
27	1	27	47.434226448	88.359424411	50.850147647	48.184672341	-0.7504459	-3.4159212	-2.665475306
28	1	28	47.933048552	100.91434202	50.850147647	48.184672341	-0.2516238	-2.9170991	-2.665475306
29	1	29	45.144287345	94.77952014	50.850147647	48.184672341	-3.040385	-5.7058603	-2.665475306
30	1	30	50.455756409	91.163033267	50.850147647	48.184672341	2.27108407	-0.3943912	-2.665475306
31	1	31	51.767555657	86.183012291	50.850147647	48.184672341	3.58288332	0.91740801	-2.665475306
32	1	32	47.738128531	94.367102999	50.850147647	48.184672341	-0.4465438	-3.1120191	-2.665475306
33	1	33	49.803496495	91.161797902	50.850147647	48.184672341	1.61882415	-1.0466512	-2.665475306

Use **PROC Mixed** to produce model output from last class (i.e., without centering)

```
*Analysis #1 - Adding school level - uncentered;
proc mixed data=school3 covtest ;
class school;
model achieve=schoolmean studentses/s ddfm=bw;
random int/subject=school g;
run;
```

Variances

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	school	18.8901	12.2688	1.54	0.0618
Residual		25.4289	1.9446	13.08	<.0001

Fit Statistics

-2 Res Log Likelihood	2147.1
AIC (smaller is better)	2151.1
AICC (smaller is better)	2151.1
BIC (smaller is better)	2151.0

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	18.6914	25.1981	5	0.74	0.4916
schoolmean	2.6161	0.5140	5	5.09	0.0038
studentses	-0.9900	0.1405	342	-7.05	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
schoolmean	1	5	25.90	0.0038
studentses	1	342	49.68	<.0001

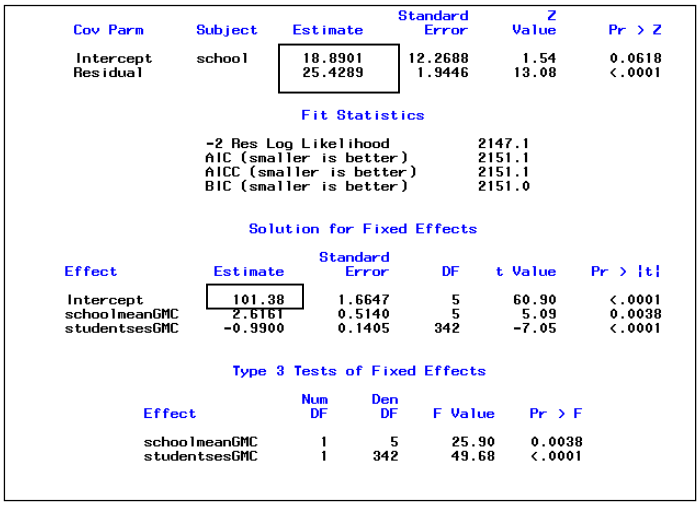
```
****Run descriptives;
ods html file='C:\descrip.xls'
style=minimal;
proc means data=school3;
var achieve studentses schoolmean;
run;
ods html close;
```

Output

Variable	N	Mean	Std Dev	Minimum	Maximum
achieve	350	101.3811912	8.5143419	81.1617979	123.7855178
studentses	350	50.8501476	3.880848	42.4146209	58.6925801
schoolmean	350	50.8501476	3.3715665	45.6638263	54.5109446

Use **PROC Mixed** to compare model without centering to model with **Grand Mean Centering. Refer to change in γ_{00};** Variances do not change.

```
*Analysis #2 - grand mean centering;
proc mixed data=school3 covtest;
class school;
model achieve=schoolmeanGMC studentsesGMC/s ddfm=bw;
random int/subject=school g;
run;
```



Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	school	18.8901	12.2688	1.54	0.0618
Residual		25.4289	1.9446	13.08	<.0001

Fit Statistics

-2 Res Log Likelihood	2147.1
AIC (smaller is better)	2151.1
AICC (smaller is better)	2151.1
BIC (smaller is better)	2151.0

Solution for Fixed Effects

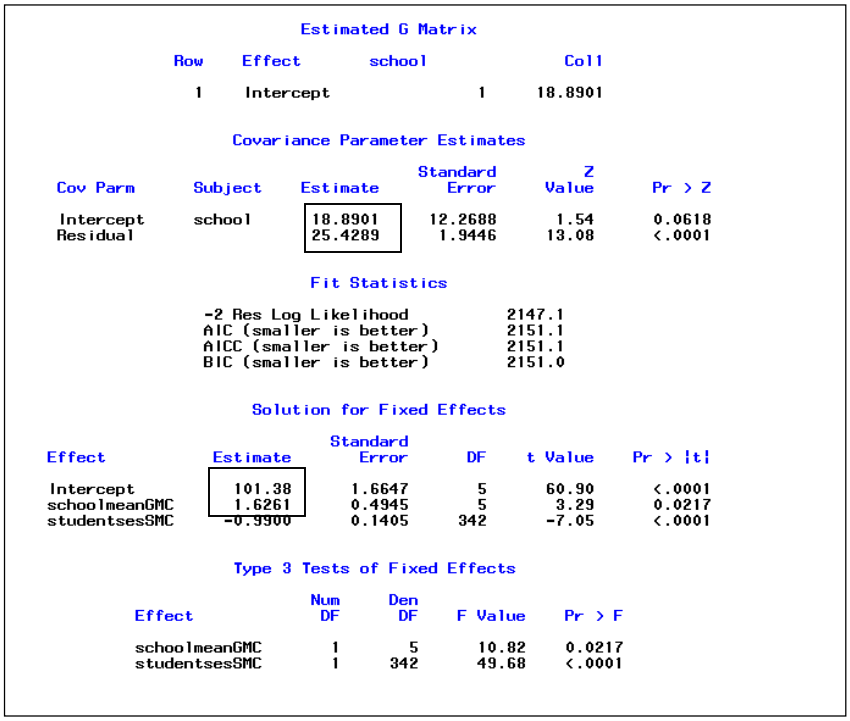
Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	1.6647	5	60.90	<.0001
schoolmeanGMC	2.6161	0.5140	5	5.09	0.0038
studentsesGMC	-0.9900	0.1405	342	-7.05	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
schoolmeanGMC	1	5	25.90	0.0038
studentsesGMC	1	342	49.68	<.0001

Use **PROC Mixed** to compare model without centering to model with **Cluster Mean Centering. Refer to change in γ_{00} & change in γ_{01};** Variances do not change.

```
*Analysis #3 cluster mean centering;
proc mixed data=school3 covtest;
class school;
model achieve=schoolmeanGMC studentsesSMC/s ddfm=bw;
random int/subject=school g;
run;
```



Estimated G Matrix

Row	Effect	school	Col1
1	Intercept	1	18.8901

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
Intercept	school	18.8901	12.2688	1.54	0.0618
Residual		25.4289	1.9446	13.08	<.0001

Fit Statistics

-2 Res Log Likelihood	2147.1
AIC (smaller is better)	2151.1
AICC (smaller is better)	2151.1
BIC (smaller is better)	2151.0

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	1.6647	5	60.90	<.0001
schoolmeanGMC	1.6261	0.4945	5	3.29	0.0217
studentsesSMC	-0.9900	0.1405	342	-7.05	<.0001

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
schoolmeanGMC	1	5	10.82	0.0217
studentsesSMC	1	342	49.68	<.0001

Create **Correlation** Matrix to ascertain why slope changes across GMC and CMC

```
ods html file='C:\cormat.xls'
style=minimal;
proc corr data=school3;
var studentses studentsesSMC studentsesGMC schoolmean schoolmeanGMC;
run;
ods html close;
```

Pearson Correlation Coefficients, N = 350 Prob > |r| under H0: Rho=0					
	studentses	**studentsesSMC**	**studentsesGMC**	**schoolmean**	**schoolmeanGMC**
studentses	1	0.49521 <.0001	1 <.0001	0.86877 <.0001	0.86877 <.0001
studentsesSMC	0.49521 <.0001	1	0.49521 <.0001	0 1	0 1
studentsesGMC	1 <.0001	0.49521 <.0001	1	0.86877 <.0001	0.86877 <.0001
schoolmean	0.86877 <.0001	0 1	0.86877 <.0001	1	1 <.0001
schoolmeanGMC	0.86877 <.0001	0 1	0.86877 <.0001	1 <.0001	1

Use **PROC MIXED** to build Model #1 or the Empty Model.

```
*model #1 - empty model Change in estimation method;
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= /s ddfm=satterthwaite;
run;
```

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Estimate	Standard Error	Z Value	Pr > Z
Residual	72.2869	5.4644	13.23	<.0001

Fit Statistics

-2 Log Likelihood	2491.5
AIC (smaller is better)	2495.5
AICC (smaller is better)	2495.5
BIC (smaller is better)	2503.2

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
0	0.00	1.0000

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	0.4545	350	223.08	<.0001

Use **PROC MIXED** to build **Model #2**

```
*model #2 - empty model + random intercept;
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= /s ddfm=satterthwaite;
random int /s type=un subject=school g gcorr v vcorr;
run;
```

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	school	43.2491	23.4281	1.85	0.0324
Residual		29.0378	2.2173	13.10	<.0001

Fit Statistics

-2 Log Likelihood	2202.5
AIC (smaller is better)	2208.5
AICC (smaller is better)	2208.6
BIC (smaller is better)	2208.4

Use in Dev Test

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	288.95	<.0001

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	2.5023	7	40.52	<.0001

Solution for Random Effects

Effect	school	Estimate	Std Err Pred	DF	t Value	Pr > |t|
Intercept	1	-8.7615	2.5826	7.93	-3.39	0.0096
Intercept	2	6.9111	2.5826	7.93	2.68	0.0283
Intercept	3	-1.7820	2.5826	7.93	-0.69	0.5099
Intercept	4	0.1301	2.5826	7.93	0.05	0.9611

Model Building by Adding Variables to the Baseline Model

CMC Model Building Using Level 1 ONLY

```
*model #2 1 CMC - empty model + random intercept + level 1 SES (CMC);
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= studentsesSMC/s ddfm=satterthwaite;
random int /s type=un subject=school;
run;
```


The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	school	43.3228	23.4281	1.85	0.0322
Residual		25.3547	1.9361	13.10	<.0001

Fit Statistics

-2 Log Likelihood	2156.0
AIC (smaller is better)	2164.0
AICC (smaller is better)	2164.1
BIC (smaller is better)	2163.8

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	317.54	<.0001

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	2.5023	7	40.52	<.0001
studentsesSMC	-0.9900	0.1402	343	-7.06	<.0001

CMC Model Building Using Level 2 ONLY

```
*model #2 2 CMC - empty model + random intercept + level 2 SES (CMC);
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= schoolmeanGMC/s ddfm=satterthwaite;
random int /s type=un subject=school;
run;
```

The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	school	13.2754	7.4066	1.79	0.0365
Residual		29.0378	2.2173	13.10	<.0001

Fit Statistics

-2 Log Likelihood	2194.5
AIC (smaller is better)	2202.5
AICC (smaller is better)	2202.6
BIC (smaller is better)	2202.3

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	109.57	<.0001

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	1.4069	7	72.06	<.0001
schoolmeanGMC	1.6261	0.4179	7	3.89	0.0060

CMC Model Building Using Level 1 & Level 2

```
*model #2 3 CMC - empty model + random intercept + level 1 & 2 SES (CMC);
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= schoolmeanGMC studentsesSMC/s ddfm=satterthwaite;
random int /s type=un subject=school;
run;
```


The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	school	13.3491	7.4065	1.80	0.0357
Residual		25.3547	1.9361	13.10	<.0001

Fit Statistics

-2 Log Likelihood	~~2147.9~~
AIC (smaller is better)	2157.9
AICC (smaller is better)	2158.1
BIC (smaller is better)	2157.7

Use in Dev Test

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	124.89	<.0001

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	1.4069	7	72.06	<.0001
schoolmeanGMC	1.6261	0.4179	7	3.89	0.0060
studentsesSMC	-0.9900	0.1402	343	-7.06	<.0001

Solution for Random Effects

Effect	school	Estimate	Std Err Pred	DF	t Value	Pr > |t|
Intercept	1	-4.3784	1.8648	8.09	-2.35	0.0465
Intercept	2	1.6524	2.0100	7.75	0.82	0.4356

GMC Model Building Using Level 1 ONLY

```
*model #2 1 GMC - empty model + random intercept + level 1 SES (GMC);
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= studentsesGMC/s ddfm=satterthwaite;
random int /s type=un subject=school;
run;
```

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	school	88.2664	48.1590	1.83	0.0334
Residual		25.3624	1.9373	13.09	<.0001

Fit Statistics

-2 Log Likelihood	2161.1
AIC (smaller is better)	2169.1
AICC (smaller is better)	2169.2
BIC (smaller is better)	2168.8

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	251.72	<.0001

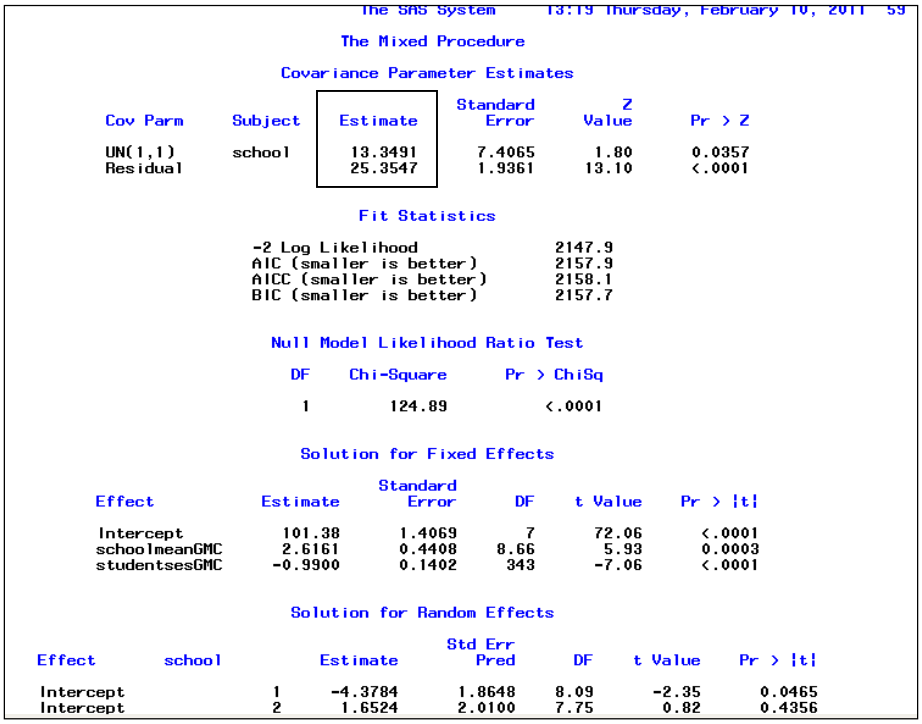
Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	3.5612	6.8	28.47	<.0001
studentsesGMC	-0.9447	0.1391	350	-6.79	<.0001

GMC Model Building Using Level 2 ONLY (same as level 2 CMC)

GMC Model Building Using Level 1 & Level 2

```
*model #2 3 GMC - empty model + random intercept + level 1 SES (GMC);
proc mixed data=school3 covtest noprofile method=ML;
class school;
model achieve= schoolmeanGMC studentsesGMC/s ddfm=satterthwaite;
random int /s type=un subject=school;
run;
```



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The Mixed Procedure

Covariance Parameter Estimates

Cov Parm	Subject	Estimate	Standard Error	Z Value	Pr > Z
UN(1,1)	school	13.3491	7.4065	1.80	0.0357
Residual		25.3547	1.9361	13.10	<.0001

Fit Statistics

-2 Log Likelihood	2147.9
AIC (smaller is better)	2157.9
AICC (smaller is better)	2158.1
BIC (smaller is better)	2157.7

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
1	124.89	<.0001

Solution for Fixed Effects

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Intercept	101.38	1.4069	7	72.06	<.0001
schoolmeanGMC	2.6161	0.4408	8.66	5.93	0.0003
studentsesGMC	-0.9900	0.1402	343	-7.06	<.0001

Solution for Random Effects

Effect	school	Estimate	Std Err Pred	DF	t Value	Pr > |t|
Intercept	1	-4.3784	1.8648	8.09	-2.35	0.0465
Intercept	2	1.6524	2.0100	7.75	0.82	0.4356