Ed.231E Statistical Analysis with Latent Variables - Assignment 2

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Outline of Assignment

Consider the LSAY math attitude items found in the data in the Assignment section of the M*plus* course web site (see Week 1, LSAY Data, Input for LSAY):

enj7-10 ...	I ENJOY MATH
good7-10 ...	I AM GOOD AT MATH
und7-10 ...	USUALLY UNDERSTAND MATH
useboy7-10 ...	MATH MORE USEFUL FOR BOYS
nerv7-10 ...	MATH MAKES ME NERVOUS
wor7-10 ...	WORRY ABOUT MATH TEST GRADES
scar7-10 ...	SCARED WHEN I OPEN MATH BOOK
use7-10 ...	MATH USEFUL IN EVERYDAY PROBLEMS
logic7-10 ...	MATH HELPS LOGICAL THINKING
boybet7-10 ...	BOYS BETTER AT MATH THAN GIRLS
job7-10 ...	NEED MATH FOR A GOOD JOB
often7-10 ...	WILL USE MATH OFTEN AS AN ADULT

where each item is measured on a 5-point Likert scale:

1-Strongly Agree, 2-Agree, 3-Not sure, 4-Disagree, 5-Strongly Disagree.

Use these data to do a series of factor analyses covering Exploratory Factor Analysis (EFA), EFA within Confirmatory Factor Analysis (CFA), and simple structure CFA. Show that the EFA within CFA has the same maximum-likelihood chi-square value and degrees of freedom as the EFA.

You may simplify by studying only one grade. Perhaps it would be interesting to do the analyses separately by gender.

For those with access to only the demo version of M*plus*, choose the subset of 6 items:

```
enj, good, und, use, job, often
```

For the EFA, use M*plus* to do an eigenvalue plot to decide on the number of factors by checking where the break in the eigenvalue curve (the "elbow") is situated and how many factors are above the "scree" of similar and small eigenvalues.

As background reading for these analyses, see (particularly the example in section 4):

Jöreskog, K.G. (1969). A general approach to confirmatory maximum likelihood factor analysis. Psychometrika, 34.

Exploratory Factor Analysis

Objectives

Exploratory Factor Analysis (EFA) is conducted to achieve the following objectives:

- Identify the number of underlying factors,
- Evaluate the quality of the measurement instrument,
- Identify variables within the measurement instrument that are performing poorly as factor indicators, and
- Identify factors that are poorly measured.

By exploring the dimensionality of a measurement model (constructed by latent variables and their indicator variables), EFA's aim is to find the smallest number of substantively meaningful/interpretable factors necessary to explain the correlation amongst a set of variables. In other words, the goal is to predict a correlation matrix that is as close to the sample correlation matrix (which can be obtained from a given dataset). No prescribed structure will be placed between the manifest (observed) variables and latent factors.

Dataset and Software

As it was outlined in the previous chapter, a subset of the "Longitudinal Study for the American Youth (LSAY)" data will be used to conduct the analysis. Due to the restriction placed on the Demo version of the M*plus* software, only six variables (`enj`, `good`, `und`, `use`, `job`, `often`) were used in the analysis per grade (Grade 7 through 10). Although it would have been ideal to run a simultaneous analysis across the four grades, separate analysis was conducted for each grade.

Correlations

The command "TYPE = basic" is used to obtain the correlation amongst the six manifest variables for each grade, as shown in Tables 1 $\sim$ 4. An examination of the values on each table reveals that higher correlation exists amongst variables "`enj`," "`good`," and "`und`," as well as amongst "`use`," "`job`," and "`often`."

Corresponding variance-covariance matrices for Tables 1 $\sim$ 4 can be found in the Appendix.

Determine the Number of Factors

The command "TYPE = EFA # #" was used to obtain estimated factor solutions. To determine the number of the smallest number of substantively meaningful/interpretable factors necessary to explain the correlation amongst the six variables (`enj`, `good`, `und`, `use`, `job`, `often`) for each grade.

Table 1: Means and Correlation Matrix for the Six Observed Variables - Grade 7

(N = 3,066)	ENJ7	GOOD7	UND7	USE7	JOB7	OFTEN7
ENJ7	1.000	-	-	-	-	-
GOOD7	0.622	1.000	-	-	-	-
UND7	0.514	0.609	1.000	-	-	-
USE7	0.271	0.266	0.278	1.000	-	-
JOB7	0.201	0.208	0.233	0.393	1.000	-
OFTEN7	0.313	0.289	0.314	0.462	0.558	1.000
MEAN	2.313	2.247	2.132	2.132	1.947	1.959

Table 2: Means and Correlation Matrix for the Six Observed Variables - Grade 8

(N = 2,675)	ENJ8	GOOD8	UND8	USE8	JOB8	OFTEN8
ENJ8	1.000					
GOOD8	0.657	1.000				
UND8	0.542	0.631	1.000			
USE8	0.317	0.236	0.260	1.000		
JOB8	0.284	0.241	0.267	0.452	1.000	
OFTEN8	0.336	0.285	0.298	0.536	0.612	1.000
MEAN	2.335	2.252	2.158	2.146	1.983	2.044

Table 3: Means and Correlation Matrix for the Six Observed Variables - Grade 9

(N = 2,360)	ENJ9	GOOD9	UND9	USE9	JOB9	OFTEN9
ENJ9	1.000					
GOOD9	0.674	1.000				
UND9	0.575	0.698	1.000			
USE9	0.345	0.322	0.318	1.000		
JOB9	0.291	0.260	0.267	0.481	1.000	
OFTEN9	0.345	0.317	0.335	0.537	0.644	1.000
MEAN	2.337	2.270	2.265	2.276	2.133	2.140

Table 4: Means and Correlation Matrix for the Six Observed Variables - Grade 10

(N = 2,260)	ENJ10	GOOD10	UND10	USE10	JOB10	OFTEN10
ENJ10	1.000					-
GOOD10	0.702	1.000				-
UND10	0.604	0.723	1.000			-
USE10	0.299	0.256	0.248	1.000		-
JOB10	0.288	0.259	0.273	0.475	1.000	-
OFTEN10	0.395	0.338	0.324	0.567	0.616	1.000
MEAN	2.516	2.398	2.366	2.361	2.223	2.234

Eigenvalues

Table 5 summarizes the eigen values obtained by EFA for each grade, while Fig. 1 is a Scree plot that illustrates the same information in a graphical format.

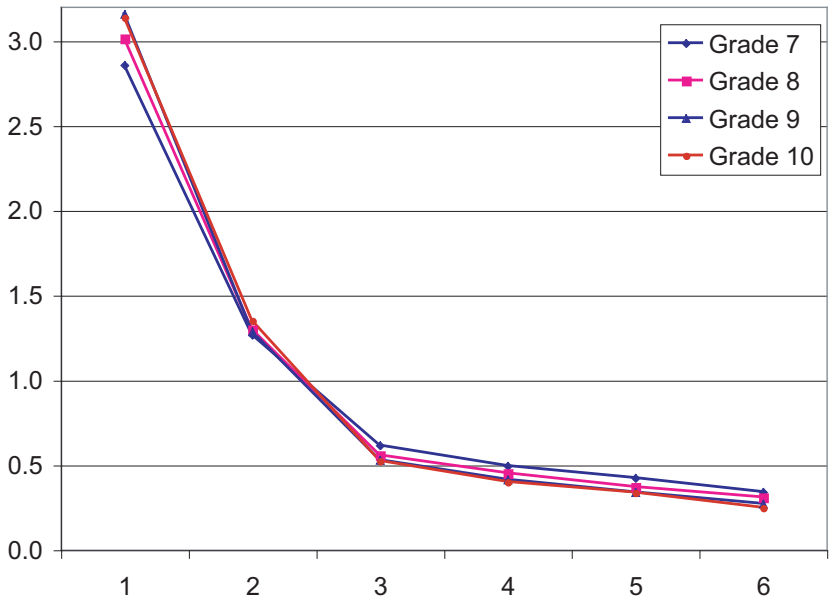

Figure 1: Scree Plot for Grade 7 through Grade 10

Table 5: Eigenvalues by Grade

	1	2	3	4	5	6
Grade 7	**2.857**	**1.268**	0.616	0.494	0.423	0.341
Grade 8	**3.014**	**1.299**	0.557	0.452	0.370	0.309
Grade 9	**3.158**	**1.287**	0.529	0.414	0.340	0.271
Grade 10	**3.138**	**1.351**	0.525	0.401	0.337	0.248

With two eigen values consistently being over 1.0, Table 5 and Fig. 1 indicates that a "2-Factor Solution" may be appropriate for each of the four grades.

Model Fit

To determine whether a "2-Factor Solution" is suitable, we examine the Model Fit statistics obtained for 1-, 2-, and 3-factor solutions. The fit statistics for the four grades are summarized in Table 6.

The χ^2 tests whether the given model fits significantly better than the model where the variables correlate freely. Thus, p-values grater than 0.05 indicates a good fit. With the exception of Grade 8 ($p = 0.003$), all grades indicate good fit ($p > .05$).

RMSEA is a function of χ^2 which also test model fit. It is generally recommended that the value be less than .05. Based on this threshold, all grades indicate a good model fit.

Finally, RMSR is the average residual for the correlation matrix. It is generally recommended that the value be less than .05. As it was with RMSEA, based on this threshold, all grades indicate a good model fit.

The composite result of these model fit statistics suggest that a "2-Factor Solution" is a suitable solution.

Table 6: Model Fit Statistics by Factor Solution - by Grade

Factors	χ^2	df	p-value	RSMEA$^+$	RMSR
	Grade 7				
1	1335.82	9	0.000	0.226	0.143
2	7.90	4	0.095	0.018	0.006
3	1.32	0	0.000	-	0.003
	Grade 8				
1	1587.46	9	0.000	0.262	0.159
2	16.22	4	0.003	0.035	0.009
3	0.00	0	0.000	-	0.000
	Grade 9				
1	1573.33	9	0.000	0.276	0.166
2	4.90	4	0.297	0.010	0.005
3	0.00	0	0.000	-	0.000
	Grade 10				
1	1603.30	9	0.000	0.285	0.180
2	8.87	4	0.064	0.024	0.007
3	0.03	0	0.000	-	0.000

$^+$ A function of χ^2 (test of fit). Value less than .05 is recommended.

$RMSEA = \sqrt{\frac{\chi^2}{n \times d} - \frac{1}{n}} \times \sqrt{g}$ ... where d is degrees of freedom, n is total sample size, and g is the number of groups.

Table 7: Estimated Error Variances by Grade - 2 Factor Solution

Grade 7	ENJ7	GOOD7	UND7	USE7	JOB7	OFTEN7
	0.476	0.242	0.503	0.662	0.530	0.329
Grade 8	ENJ8	GOOD8	UND8	USE8	JOB8	OFTEN8
	0.415	0.220	0.482	0.588	0.480	0.283
Grade 9	ENJ9	GOOD9	UND9	USE9	JOB9	OFTEN9
	0.429	0.179	0.394	0.578	0.417	0.272
Grade 10	ENJ10	GOOD10	UND10	USE10	JOB10	OFTEN10
	0.403	0.151	0.379	0.559	0.479	0.246

Table 7 illustrates that no negative error variance is present for the "2 Factor Solution."

Determining and Interpreting the Factors

Table 8 summarizes the factor loadings for the six manifest variables on the two factors, which we will refer to as η_1 and η_2. It shows the factor loadings for PROMAX Rotation (where $\text{Cov}(\eta_1, \eta_2) \neq 0$) as well as for VARIMAX Rotation (where $\text{Cov}(\eta_1, \eta_2) = 0$)

By examining the factor loadings under PROMAX Rotation, variables `enj`, `good`, and `und` loads high on η_1, while variables `use`, `job`, and `often` loads high on η_2 across all grades. This pattern can be observed for factor loadings under VARIMAX Rotation across all grades. Cross loading of indicator variables does not appear to be an issue.

Based on these results, we propose the measurement model where factor η_1 is measured by indicator variables `enj`, `good`, and `und`, while factor η_2 is measured by indicator variables variables `use`, `job`, and `often`. Thus, the model to be further evaluated under the following "Exploratory Factor Analysis in Confirmatory Factor Analysis" framework can be illustrated as in Fig. 2.

Let us examining the indicator variables for η_1:

enj7-10 ... I ENJOY MATH

good7-10 ... I AM GOOD AT MATH

und7-10 ... USUALLY UNDERSTAND MATH

These items share the similarity of tapping into the construct of measuring "*positive attitude towards the subject of math*". In the following analysis, we will refer to this factor as `ATTITUDE`.

Similarly, the indicator variables for η_2 are:

use7-10 ... MATH USEFUL IN EVERYDAY PROBLEMS

job7-10 ... NEED MATH FOR A GOOD JOB

often7-10 ... WILL USE MATH OFTEN AS AN ADULT

These items share the similarity of tapping into the construct of measuring "*how necessary a subject of math is to the subject*". In the following analysis, we will refer to this factor as `NECESSIT`.

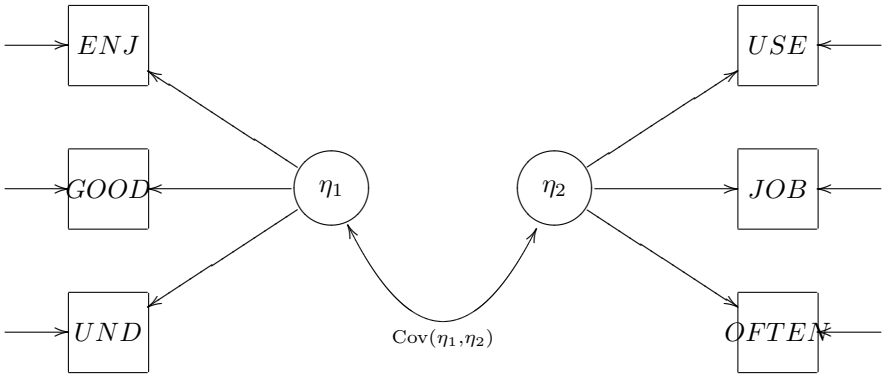

Figure 2: Proposed Measurement Model

Table 8: Promax/Varimax Factor Loading for 2 Factor Solution - Grade 7 through 10

PROMAX ROTATED LOADINGS

	Grade 7			Grade 8			Grade 9			Grade 10	
	η_1	η_2		η_1	η_2		η_1	η_2		η_1	η_2
ENJ7	**0.702**	0.044	ENJ8	**0.717**	0.092	ENJ9	**0.714**	0.079	ENJ10	**0.715**	0.113
GOOD7	**0.898**	-0.062	GOOD8	**0.918**	-0.079	GOOD9	**0.937**	-0.066	GOOD10	**0.944**	-0.052
UND7	**0.672**	0.066	UND8	**0.694**	0.052	UND9	**0.763**	0.031	UND10	**0.781**	0.017
USE7	0.085	**0.537**	USE8	0.038	**0.624**	USE9	0.112	**0.588**	USE10	0.005	**0.662**
JOB7	-0.060	**0.712**	JOB8	-0.018	**0.729**	JOB9	-0.055	**0.789**	JOB10	-0.020	**0.731**
OFTEN7	-0.008	**0.823**	OFTEN8	-0.022	**0.857**	OFTEN9	-0.021	**0.864**	OFTEN10	0.010	**0.864**

PROMAX FACTOR CORRELATIONS

	Grade 7			Grade 8			Grade 9			Grade 10	
	η_1	η_2		η_1	η_2		η_1	η_2		η_1	η_2
1	1.000	-	1	1.000	-	1	1.000	-	1	1.000	-
2	0.474	1.000	2	0.469	1.000	2	0.484	1.000	2	0.454	1.000

VARIMAX ROTATED LOADINGS

	Grade 7			Grade 8			Grade 9			Grade 10	
	η_1	η_2		η_1	η_2		η_1	η_2		η_1	η_2
ENJ7	**0.693**	0.209	ENJ8	**0.721**	0.256	ENJ9	**0.712**	0.252	ENJ10	**0.725**	0.267
GOOD7	**0.857**	0.152	GOOD8	**0.873**	0.137	GOOD9	**0.891**	0.166	GOOD10	**0.908**	0.157
UND7	**0.669**	0.222	UND8	**0.688**	0.211	UND9	**0.747**	0.218	UND10	**0.765**	0.188
USE7	0.218	**0.539**	USE8	0.193	**0.612**	USE9	0.258	**0.597**	USE10	0.168	**0.643**
JOB7	0.121	**0.675**	JOB8	0.166	**0.702**	JOB9	0.147	**0.749**	JOB10	0.160	**0.704**
OFTEN7	0.201	**0.794**	OFTEN8	0.194	**0.824**	OFTEN9	0.199	**0.830**	OFTEN10	0.222	**0.839**

EFA within CFA

Objectives

Exploratory Factor Analysis (EFA) in a Confirmatory Factor Analysis (CFA) framework is conducted to achieve the following objectives:

- To obtain standard errors to determine whether factor loadings are statistically significant, and
- To obtain modification indices to determine whether residual covariances are needed to represent minor factors.

Model Fit

The following analyses will be conducted under "Oblique" solution. Under the "Oblique" solution, the two factors `ATTITUDE` and `NECESSIT` are assumed to be correlated ($\text{Cov}(\texttt{ATTITUDE}, \texttt{NECESSIT}) \neq 0$) and will be freely estimated. In addition, as previously stated, the variance of the two factors are set to be 1.0. One anchor item will become necessary for each factor, because the covariance is not fixed to zero.

The opposite of an "Oblique" solution is referred to as an "Orthogonal" solution, where the two factors `ATTITUDE` and `NECESSIT` are assumed to be uncorrelated ($\text{Cov}(\texttt{ATTITUDE}, \texttt{NECESSIT}) = 0$). Because the factors are assumed to be uncorrelated, the factor covariance matrix is thereby fixed. In order to fix the coordinate space, in this given case, only one anchor item will be necessary. Table 9 summarizes the differences between the "Oblique" and "Orthogonal" solutions in terms of factor covariance matrix Ψ and factor loadings Λ.

Anchor Items

To achieve these objectives, the same number of restrictions will be placed on the model as in the previous EFA model (m^2 restrictions, where m is the number of factors in the model).

Specifically, the variance of each of the factors `ATTITUDE` and `NECESSIT` is fixed at 1.0 (In general, this would add up to be m restrictions for the model). Further more, based on its factor loadings, an anchor item will be selected from the indicator variables for each factor. The factor loading of an anchor item for other factors will be fixed to zero (In general, this would add up to be $m^2 - m$ restrictions for the model, making the total number of restriction placed on the model to be m^2).

By examining the factor loadings on Table 8, it is clear that the indicator variable `good` is most suitable[1] as the anchor item for factor `ATTITUDE` (η_1), while the indicator variable `often` is most suitable as the anchor item for factor `NECESSIT` (η_2).

[1] An anchor item should have a large loading amongst the indicator variables for the factor, as well as small loading for the other factor.

Table 9: Orthogonal and Oblique Solutions - Difference in Specifications

Orthogonal Solution	Oblique Solution
$\Lambda = \begin{bmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \\ \vdots & \vdots \\ \vdots & 0 \\ \lambda_{n1} & \lambda_{n2} \end{bmatrix}$	$\Lambda = \begin{bmatrix} \lambda_{11} & \lambda_{12} \\ 0 & \vdots \\ \lambda_{31} & \vdots \\ \vdots & 0 \\ \lambda_{n1} & \lambda_{n2} \end{bmatrix}$
$\Psi = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$	$\Psi = \begin{bmatrix} 1 & \text{Cov}(\eta_1, \eta_2) \\ \text{Cov}(\eta_2, \eta_1) & 1 \end{bmatrix}$

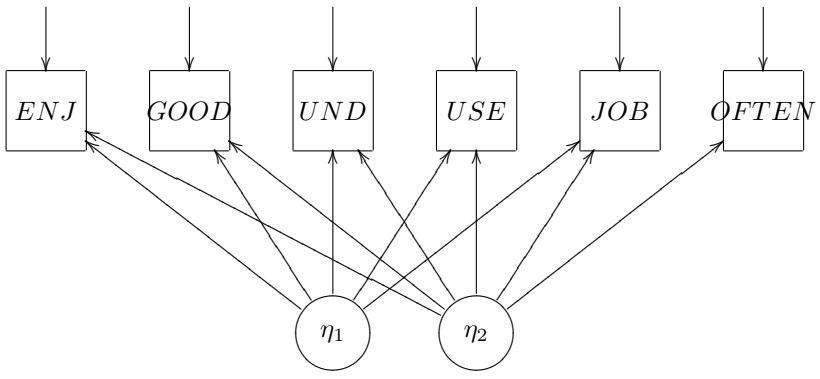

Figure 3: Orthogonal Solution

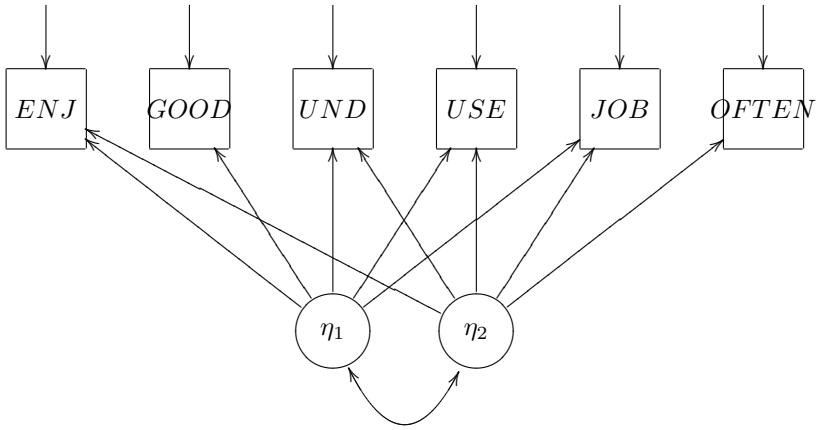

Figure 4: Oblique Solution

Table 10 summarizes the model fit statistics for each of the four grades under the orthogonal and oblique solutions respectively. The model fit statistic is identical to what was obtained with EFA.

As it was previously explained, the χ^2 tests whether the given model fits significantly better than the model where the variables correlate freely. Thus, p-values grater than 0.05 indicates a good fit. With the exception of Grade 8 ($p = 0.003$), all grades indicate good fit ($p > .05$).

CFI is a χ^2 comparison of the target model to the baseline model. It is generally recommended that the value be equal or greater than .96/.95. All grades have values well above .96 under the "Oblique" solution, indicating good model fit.

TLI is another form of χ^2 comparison of the target model to the baseline model. It is generally recommended that the value be equal or greater than .95/.95. All grades have values well above .95 under the "Oblique" solution, indicating good model fit.

RMSEA is a function of χ^2 which also test model fit. It is generally recommended that the value be less than .05. Based on this threshold, all grades indicate a good model fit under the "Oblique" solution.

SRMSR is the average residual for the correlation matrix. It is generally recommended that the value be less than or equal to .07/.08. Based on this threshold, all grades indicate a good model fit under the "Oblique" solution.

The composite result of these model fit statistics suggest that a model that allows covariance between the two factor fits the data well.

Factor Determinacy indicates how close the average estimate is to the true factor score. It is generally desirable to have a value of 0.80 or higher. According to Table 11, the "Oblique" solutions have estimates close to true factor scores.

Factor Loadings

The model results for "Oblique" solution is summarize by grade in Table 12 $\sim$ 15.

Table 10: Test of Model Fit by Grade - Oblique

	Grade 7	Grade 8	Grade 9	Grade 10
Number of observations	2,874	2,549	2,280	2,184
χ^2 Test of Model Fit				
Value	7.899	16.220	4.899	8.870
Degrees of Freedom	4	4	4	4
P-Value	0.0950	0.0027	0.2972	0.0642
χ^2 Test of Model Fit for the Baseline Model				
Value	5279.949	5572.756	5700.130	5670.080
Degrees of Freedom	15	15	15	15
P-Value	0.0000	0.0000	0.0000	0.0000
CFI/TLI				
CFI	0.999	0.998	1.000	0.999
TLI	0.997	0.992	0.999	0.997
Loglikelihood				
H0 Value	-22068.871	-19135.915	-16255.366	-15812.409
H1 Value	-22064.922	-19127.805	-16252.917	-15807.974
Information Criteria				
Number of Free Parameters	17	17	17	17
Akaike (AIC)	44171.743	38305.830	32544.733	31658.817
Bayesian (BIC)	44273.122	38405.168	32642.176	31755.529
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	44219.107	38351.155	32588.164	31701.518
RMSEA (Root Mean Square Error Of Approximation)				
Estimate	0.018	0.035	0.010	0.024
90 Percent C.I.	[0.000 0.037]	[0.018 0.053]	[0.000 0.034]	[0.000 0.045]
Probability RMSEA $\leq$ .05	0.998	0.912	0.999	0.982
SRMR (Standardized Root Mean Square Residual)				
Value	0.005	0.008	0.005	0.006

Table 11: Factor Determinacies by Grade - Oblique

	Grade 7	Grade 8	Grade 9	Grade 10
ATTITUDE	0.915	0.924	0.938	0.946
NECESSIT	0.886	0.905	0.913	0.917

Table 12: Model Reuslts for Grade 7 - Oblique

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameter	StdYX
ATTITUDE BY					
ENJ7	**0.814**	**0.025**	**31.937**	**0.814**	**0.681**
GOOD7	**0.902**	**0.019**	**47.113**	**0.902**	**0.870**
UND7	**0.628**	**0.020**	**30.899**	**0.628**	**0.652**
USE7	0.087	0.023	3.870	0.087	0.087
JOB7	-0.050	0.023	-2.132	-0.050	-0.052
OFTEN7	0.000	0.000	0.000	0.000	0.000
NECESSIT BY					
ENJ7	0.110	0.025	4.447	0.110	0.092
GOOD7	0.000	0.000	0.000	0.000	0.000
UND7	0.107	0.020	5.374	0.107	0.112
USE7	**0.543**	**0.023**	**23.455**	**0.543**	**0.541**
JOB7	**0.678**	**0.025**	**27.038**	**0.678**	**0.705**
OFTEN7	**0.772**	**0.020**	**38.378**	**0.772**	**0.819**
ATTITUDE WITH					
NECESSIT	0.411	0.025	16.473	0.411	0.411
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ7	0.680	0.025	27.508	0.680	0.476
GOOD7	0.261	0.022	11.826	0.261	0.242
UND7	0.466	0.016	29.196	0.466	0.503
USE7	0.668	0.021	32.234	0.668	0.662
JOB7	0.490	0.021	22.882	0.490	0.530
OFTEN7	0.292	0.023	12.615	0.292	0.329

Table 13: Model Reuslts for Grade 8 - Oblique

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameter	StdYX
ATTITUDE BY					
ENJ8	**0.800**	**0.024**	**33.427**	**0.800**	**0.694**
GOOD8	**0.924**	**0.020**	**46.953**	**0.924**	**0.883**
UND8	**0.660**	**0.021**	**31.762**	**0.660**	**0.671**
USE8	0.051	0.022	2.349	0.051	0.051
JOB8	0.001	0.021	0.035	0.001	0.001
OFTEN8	0.000	0.000	0.000	0.000	0.000
NECESSIT BY					
ENJ8	0.176	0.023	7.770	0.176	0.153
GOOD8	0.000	0.000	0.000	0.000	0.000
UND8	0.109	0.020	5.425	0.109	0.111
USE8	**0.616**	**0.022**	**27.460**	**0.616**	**0.621**
JOB8	**0.691**	**0.023**	**30.706**	**0.691**	**0.721**
OFTEN8	**0.817**	**0.019**	**41.961**	**0.817**	**0.847**
ATTITUDE WITH					
NECESSIT	0.377	0.025	15.193	0.377	0.377
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ8	0.550	0.022	25.225	0.550	0.414
GOOD8	0.240	0.022	11.053	0.240	0.220
UND8	0.466	0.017	27.877	0.466	0.482
USE8	0.578	0.020	29.278	0.578	0.588
JOB8	0.441	0.019	23.457	0.441	0.480
OFTEN8	0.263	0.021	12.529	0.263	0.283

Table 14: Model Reuslts for Grade 9 - Oblique

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameter	StdYX
ATTITUDE BY					
ENJ9	**0.775**	**0.024**	**32.588**	**0.775**	**0.694**
GOOD9	**0.882**	**0.018**	**48.677**	**0.882**	**0.906**
UND9	**0.718**	**0.021**	**34.324**	**0.718**	**0.740**
USE9	0.117	0.021	5.472	0.117	0.122
JOB9	-0.032	0.021	-1.488	-0.032	-0.035
OFTEN9	0.000	0.000	0.000	0.000	0.000
NECESSIT BY					
ENJ9	0.143	0.023	6.358	0.143	0.128
GOOD9	0.000	0.000	0.000	0.000	0.000
UND9	0.082	0.019	4.218	0.082	0.085
USE9	**0.567**	**0.022**	**25.513**	**0.567**	**0.590**
JOB9	**0.711**	**0.023**	**30.729**	**0.711**	**0.777**
OFTEN9	**0.804**	**0.020**	**40.990**	**0.804**	**0.853**
ATTITUDE WITH					
NECESSIT	0.408	0.025	16.438	0.408	0.408
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ9	0.535	0.020	26.500	0.535	0.429
GOOD9	0.169	0.017	10.022	0.169	0.179
UND9	0.371	0.015	24.257	0.371	0.394
USE9	0.533	0.018	28.941	0.533	0.578
JOB9	0.349	0.018	19.263	0.349	0.417
OFTEN9	0.241	0.020	11.966	0.241	0.272

Table 15: Model Reuslts for Grade 10 - Oblique

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameter	StdYX
ATTITUDE BY					
ENJ10	**0.818**	**0.025**	**33.048**	**0.818**	**0.697**
GOOD10	**0.954**	**0.019**	**49.818**	**0.954**	**0.922**
UND10	**0.773**	**0.022**	**35.081**	**0.773**	**0.761**
USE10	-0.002	0.022	-0.103	-0.002	-0.002
JOB10	-0.026	0.021	-1.214	-0.026	-0.028
OFTEN10	0.000	0.000	0.000	0.000	0.000
NECESSIT BY					
ENJ10	0.179	0.023	7.780	0.179	0.153
GOOD10	0.000	0.000	0.000	0.000	0.000
UND10	0.061	0.020	3.041	0.061	0.060
USE10	**0.626**	**0.023**	**27.145**	**0.626**	**0.665**
JOB10	**0.680**	**0.023**	**29.359**	**0.680**	**0.733**
OFTEN10	**0.825**	**0.020**	**41.768**	**0.825**	**0.868**
ATTITUDE WITH					
NECESSIT	0.417	0.024	17.292	0.417	0.417
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ10	0.555	0.021	26.064	0.555	0.403
GOOD10	0.161	0.018	8.866	0.161	0.151
UND10	0.390	0.016	23.708	0.390	0.379
USE10	0.494	0.019	26.523	0.494	0.559
JOB10	0.413	0.018	22.837	0.413	0.479
OFTEN10	0.222	0.020	11.020	0.222	0.246

All Est./S.E. values for the indicator variables are greater than 1.96, indicating that they are statistically significant. While cross-loading of indicator variables can be observed across grades, their Est./S.E. values are considerably smaller than those for the indicator variables.

Table 16: R^2 by Grade - Oblique

Oblique							
Observed Variable	R^2	Observed Variable	R^2	Observed Variable	R^2	Observed Variable	R^2
ENJ7	0.524	ENJ8	0.586	ENJ9	0.571	ENJ10	0.597
GOOD7	0.758	GOOD8	0.780	GOOD9	0.821	GOOD10	0.849
UND7	0.497	UND8	0.518	UND9	0.606	UND10	0.621
USE7	0.338	USE8	0.412	USE9	0.422	USE10	0.441
JOB7	0.470	JOB8	0.520	JOB9	0.583	JOB10	0.521
OFTEN7	0.671	OFTEN8	0.717	OFTEN9	0.728	OFTEN10	0.754

$R^2 = 1 - \text{STDYX} = \text{Reliability}$.

Modification Indices

Modification indices could be useful in determining whether residual covariances are needed to represent minor factors. From Table 17, residual covariances such as Cov(`UND`, `GOOD`), which comes up in every grade except grade 7, could be an additional structure that makes substantial sense. However, it would be ideal to determine which residual covariances to add to the model, based on a simultaneous estimation that involves all four grades. Since no persistent residual covariance was identified across grade levels, non will be added to the model.

Table 17: Modification Indices by Grade - Oblique

Grade 7	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
WITH Statements				
JOB7 WITH ENJ7	6.917	-0.037	-0.037	-0.033
JOB7 WITH GOOD7	5.089	0.031	0.031	0.031
OFTEN7 WITH ENJ7	4.326	0.031	0.031	0.027
OFTEN7 WITH USE7	4.027	-0.117	-0.117	-0.124
Grade 8	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
WITH Statements				
UND8 WITH ENJ8	12.376	-0.529	-0.529	-0.467
UND8 WITH GOOD8	13.203	0.750	0.750	0.730
USE8 WITH ENJ8	13.090	0.050	0.050	0.044
USE8 WITH GOOD8	12.096	-0.046	-0.046	-0.045
JOB8 WITH USE8	5.464	-0.089	-0.089	-0.093
OFTEN8 WITH GOOD8	5.428	0.032	0.032	0.031
OFTEN8 WITH JOB8	13.950	0.254	0.254	0.274
Grade 9	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
WITH Statements				
UND9 WITH GOOD9	4.112	0.167	0.167	0.177
USE9 WITH ENJ9	4.088	0.027	0.027	0.025
Grade 10	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
WITH Statements				
GOOD10 WITH ENJ10	4.583	-0.920	-0.920	-0.757
UND10 WITH GOOD10	5.973	1.113	1.113	1.060
JOB10 WITH ENJ10	5.890	-0.031	-0.031	-0.029
JOB10 WITH UND10	4.638	0.023	0.023	0.025

Confirmatory Factor Analysis

Simple Structure CFA

Based on the preceding EFA and EFA in a CFA framework, we estimate the model illustrated in Fig. 2 using CFA. Unlike in the EFA and EFA in a CFA framework, CFA specifies which indicator variables measure what factor. There is a clear separation, as is clear from the M*plus* model statement (please see Appendix for details).

While χ^2 test indicates poor fit for every grade level, both CFI and TLI indicate good model fit across grades ($\leq .96$, $\leq .95$ respectively). RMSEA values are around the borderline value of .05, while SRMR values are clearly below .07 indicating good fit.

Overall the values tend to fluctuate from grade to grade. We suspect that a better estimates can be obtained, had all the variables been included in a single simultaneous analysis. For the sake of this exercise, however, we will conclude that composite result of these model fit statistics indicate good fit.

As it was previously stated, Factor Determinacy indicates how close the average estimate is to the true factor score. It is generally desirable to have a value of 0.80 or higher. According to Table 19, the estimates for each grade are close to the true factor score.

Factor Loadings

The model results is summarized by grade in Table 20 $\sim$ 23. All Est./S.E. values for the indicator variables are greater than 1.96, indicating that they are statistically significant. It is also important to note that the covariance between the two factors, `ATTITUDE` and `NECESSIT`, is also statistically significant.

Modification Indices

As it was previously stated, it would be ideal to determine which regression/covariances to add to the model, based on a simultaneous estimation that involves all four grades. Issues, such as "measurement invariance," could be investigated under such circumstances.

Table 18: Test of Model Fit by Grade - CFA

	Grade 7	Grade 8	Grade 9	Grade 10
Number of observations	2,874	2,549	2,280	2,184
χ^2 Test of Model Fit				
Value	72.416	86.413	90.920	68.195
Degrees of Freedom	8	8	8	8
P-Value	0.0000	0.0000	0.0000	0.0000
χ^2 Test of Model Fit for the Baseline Model				
Value	5279.949	5572.756	5700.130	5670.080
Degrees of Freedom	15	15	15	15
P-Value	0.0000	0.0000	0.0000	0.0000
CFI/TLI				
CFI	0.988	0.986	0.985	0.989
TLI	0.977	0.974	0.973	0.980
Loglikelihood				
H0 Value	-22101.130	-19171.012	-16298.377	-15842.072
H1 Value	-22064.922	-19127.805	-16252.917	-15807.974
Information Criteria				
Number of Free Parameters	13	13	13	13
Akaike (AIC)	44228.260	38368.023	32622.754	31710.143
Bayesian (BIC)	44305.785	38443.988	32697.269	31784.099
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	44264.479	38402.684	32655.966	31742.796
RMSEA (Root Mean Square Error Of Approximation)				
Estimate	0.053	0.062	0.067	0.059
90 Percent C.I.	[0.042 0.064]	[0.051 0.074]	[0.055 0.080]	[0.046 0.072]
Probability RMSEA $\leq$ .05	0.311	0.042	0.009	0.120
SRMR (Standardized Root Mean Square Residual)				
Value	0.029	0.029	0.037	0.026

Table 19: Factor Determinacies by Grade - Orthogonal and Oblique Rotations

	Grade 7	Grade 8	Grade 9	Grade 10
ATTITUDE	0.911	0.919	0.933	0.941
NECESSIT	0.885	0.905	0.912	0.916

Table 20: Model Reuslts for Grade 7 - CFA

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameters	StdYX
ATTITUDE BY					
ENJ7	0.880	0.021	41.364	0.880	0.736
GOOD7	0.873	0.018	48.380	0.873	0.842
UND7	0.691	0.017	40.120	0.691	0.717
NECESSIT BY					
USE7	0.590	0.020	29.996	0.590	0.587
JOB7	0.648	0.019	34.543	0.648	0.674
OFTEN7	0.772	0.018	41.726	0.772	0.819
ATTITUDE WITH					
NECESSIT	0.472	0.020	24.144	0.472	0.472
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ7	0.654	0.024	27.232	0.654	0.458
GOOD7	0.313	0.018	17.400	0.313	0.291
UND7	0.451	0.016	28.547	0.451	0.486
USE7	0.662	0.021	31.592	0.662	0.655
JOB7	0.504	0.019	26.933	0.504	0.546
OFTEN7	0.292	0.020	14.901	0.292	0.329

Table 21: Model Reuslts for Grade 8 - CFA

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameters	StdYX
ATTITUDE BY					
ENJ8	0.900	0.021	42.812	0.900	0.781
GOOD8	0.885	0.019	47.242	0.885	0.846
UND8	0.719	0.018	39.521	0.719	0.732
NECESSIT BY					
USE8	0.638	0.020	32.582	0.638	0.644
JOB8	0.692	0.019	36.930	0.692	0.721
OFTEN8	0.815	0.019	43.867	0.815	0.844
ATTITUDE WITH					
NECESSIT	0.470	0.020	23.618	0.470	0.470
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ8	0.517	0.022	23.859	0.517	0.390
GOOD8	0.311	0.018	17.649	0.311	0.285
UND8	0.449	0.016	27.394	0.449	0.465
USE8	0.576	0.020	29.272	0.576	0.586
JOB8	0.441	0.018	24.940	0.441	0.480
OFTEN8	0.267	0.019	14.332	0.267	0.287

Table 22: Model Reuslts for Grade 9 - CFA

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameters	StdYX
ATTITUDE BY					
ENJ9	0.853	0.021	40.424	0.853	0.764
GOOD9	0.858	0.018	48.766	0.858	0.881
UND9	0.767	0.018	42.188	0.767	0.790
NECESSIT BY					
USE9	0.627	0.020	31.820	0.627	0.652
JOB9	0.692	0.018	37.664	0.692	0.756
OFTEN9	0.801	0.019	43.092	0.801	0.850
ATTITUDE WITH					
NECESSIT	0.477	0.020	23.600	0.477	0.477
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ9	0.518	0.020	25.726	0.518	0.416
GOOD9	0.211	0.014	14.872	0.211	0.223
UND9	0.354	0.015	23.939	0.354	0.376
USE9	0.530	0.019	28.107	0.530	0.574
JOB9	0.359	0.016	22.366	0.359	0.428
OFTEN9	0.246	0.017	14.186	0.246	0.277

Table 23: Model Reuslts for Grade 10 - CFA

	Parameter Estimates	Std. Err.	Est. /S.E.	Std. Parameters	StdYX
ATTITUDE BY					
ENJ10	0.916	0.022	41.062	0.916	0.780
GOOD10	0.929	0.019	49.768	0.929	0.898
UND10	0.811	0.019	42.419	0.811	0.799
NECESSIT BY					
USE10	0.623	0.020	31.671	0.623	0.663
JOB10	0.667	0.019	34.670	0.667	0.718
OFTEN10	0.829	0.019	43.186	0.829	0.872
ATTITUDE WITH					
NECESSIT	0.460	0.021	22.274	0.460	0.460
Variances					
ATTITUDE	1.000	0.000	0.000	1.000	1.000
NECESSIT	1.000	0.000	0.000	1.000	1.000
Residual Variances					
ENJ10	0.541	0.021	25.184	0.541	0.392
GOOD10	0.207	0.015	13.570	0.207	0.193
UND10	0.372	0.016	23.822	0.372	0.361
USE10	0.495	0.018	27.019	0.495	0.560
JOB10	0.417	0.017	24.204	0.417	0.484
OFTEN10	0.217	0.019	11.590	0.217	0.240

Table 24: R^2 by Grade - CFA

Grade 7		Grade 8		Grade 9		Grade 10	
Observed Variable	R-Square	Observed Variable	R-Square	Observed Variable	R-Square	Observed Variable	R-Square
ENJ7	0.542	ENJ8	0.610	ENJ9	0.584	ENJ10	0.608
GOOD7	0.709	GOOD8	0.715	GOOD9	0.777	GOOD10	0.807
UND7	0.514	UND8	0.535	UND9	0.624	UND10	0.639
USE7	0.345	USE8	0.414	USE9	0.426	USE10	0.440
JOB7	0.454	JOB8	0.520	JOB9	0.572	JOB10	0.516
OFTEN7	0.671	OFTEN8	0.713	OFTEN9	0.723	OFTEN10	0.760

$R^2 = 1 - \text{STDYX} = \text{Reliability}$.

Table 25: Modification Indices for Grade 7 and 8 - CFA

Grade 7	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
BY Statements				
ATTITUDE BY USE7	25.267	0.115	0.115	0.114
ATTITUDE BY JOB7	16.479	-0.091	-0.091	-0.094
NECESSIT BY ENJ7	6.777	0.065	0.065	0.054
NECESSIT BY GOOD7	33.388	-0.129	-0.129	-0.125
NECESSIT BY UND7	15.103	0.078	0.078	0.081
WITH Statements				
GOOD7 WITH ENJ7	15.101	0.143	0.143	0.115
UND7 WITH ENJ7	33.393	-0.148	-0.148	-0.128
UND7 WITH GOOD7	6.784	0.073	0.073	0.073
USE7 WITH UND7	4.031	0.024	0.024	0.025
JOB7 WITH ENJ7	5.350	-0.031	-0.031	-0.027
OFTEN7 WITH ENJ7	8.224	0.036	0.036	0.032
OFTEN7 WITH GOOD7	15.100	-0.041	-0.041	-0.042
OFTEN7 WITH USE7	16.452	-0.105	-0.105	-0.111
OFTEN7 WITH JOB7	25.308	0.160	0.160	0.177
Grade 8	**M.I.**	**E.P.C.**	**Std E.P.C.**	**StdYX E.P.C.**
BY Statements				
ATTITUDE BY USE8	8.935	0.066	0.066	0.067
NECESSIT BY ENJ8	34.121	0.138	0.138	0.119
NECESSIT BY GOOD8	58.558	-0.166	-0.166	-0.159
NECESSIT BY UND8	6.241	0.051	0.051	0.052
WITH Statements				
GOOD8 WITH ENJ8	6.238	0.093	0.093	0.078
UND8 WITH ENJ8	58.555	-0.202	-0.202	-0.178
UND8 WITH GOOD8	34.130	0.161	0.161	0.157
USE8 WITH ENJ8	22.957	0.064	0.064	0.056
USE8 WITH GOOD8	8.015	-0.033	-0.033	-0.032
OFTEN8 WITH GOOD8	5.195	-0.024	-0.024	-0.023
OFTEN8 WITH JOB8	8.943	0.097	0.097	0.105

Table 26: Modification Indices for Grade 9 and 10 - CFA

Grade 9	M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
BY Statements				
ATTITUDE BY USE9	41.974	0.142	0.142	0.147
ATTITUDE BY JOB9	13.733	-0.077	-0.077	-0.084
NECESSIT BY ENJ9	25.964	0.117	0.117	0.105
NECESSIT BY GOOD9	37.839	-0.122	-0.122	-0.125
NECESSIT BY UND9	3.863	0.039	0.039	0.040
WITH Statements				
GOOD9 WITH ENJ9	3.862	0.060	0.060	0.055
UND9 WITH ENJ9	37.842	-0.150	-0.150	-0.139
UND9 WITH GOOD9	25.966	0.146	0.146	0.154
USE9 WITH ENJ9	11.861	0.045	0.045	0.042
JOB9 WITH GOOD9	5.148	-0.020	-0.020	-0.023
OFTEN9 WITH GOOD9	11.659	-0.031	-0.031	-0.033
OFTEN9 WITH USE9	13.732	-0.090	-0.090	-0.100
OFTEN9 WITH JOB9	41.975	0.203	0.203	0.235
Grade 10	**M.I.**	**E.P.C.**	**Std E.P.C.**	**StdYX E.P.C.**
BY Statements				
NECESSIT BY ENJ10	48.581	0.162	0.162	0.138
NECESSIT BY GOOD10	38.771	-0.124	-0.124	-0.120
WITH Statements				
UND10 WITH ENJ10	38.777	-0.170	-0.170	-0.143
UND10 WITH GOOD10	48.595	0.228	0.228	0.217
USE10 WITH ENJ10	4.201	0.027	0.027	0.024
JOB10 WITH UND10	4.337	0.022	0.022	0.023
OFTEN10 WITH ENJ10	22.002	0.055	0.055	0.049
OFTEN10 WITH GOOD10	4.858	-0.021	-0.021	-0.021

M*plus* Code: EFA

```
Title:  This is a partial input file for HW1 that will now be used
        for HW2.  The variable names are for the data set lsay.dat.
        "Type = Basic" for Grade 7.

DATA:   FILE IS C:\Ed.231E\Assignment_02\lsay.dat;

VARIABLE:  Names are lsayid schcode
                !lsayid = student id
                !schcode = 7th grade school code

                classize urban tracking ntracks
                !classize = 7th grade school size
                !urban = 7th grade community type
                !    (1=urban, 2=suburban, 3=rural)
                !tracking = 7th grade math tracking indicator
                !    (0=no ability grouping, 1=ability grouping)
                !ntracks = # of 7th grade math ability levels

                mthlvl female mthflg7-mthflg12 mothed fathed mothsei
                fathsei homeres race
                !mthlvl = 7th grade ability ranking
                !    (0 = no groups, 1=low, 2=middle, 3=high)
                !female
                !    (0=male, 1=female)
                !mthflg7-mthflg12 = math test availability
                !    (0=not available, 1=available)
                !mothed = mother's education
                !    (1=LT HS diploma, 2=HS diploma, 3=Some college,
                !     4=4yr college degree, 5=advanced degree)
                !fathed = father's education
                !    (1=LT HS diploma, 2=HS diploma, 3=Some college,
                !     4=4yr college degree, 5=advanced degree)
                !mothsei = mother's SEI
                !fathsei = father's SEI
                !homeres = Home math and science resources
                !race
                !    (1=Hispanic, 2=Black, 3=White, 4=Asian,
                !     5=Native American, 6=other)

                expect parapsh parcpsh parmpsh peerapsh peermpsh
                !expect = Student's educational expectations
                !  (1=HS only, 2=Vocational training,
                !   3=some college, 4=Bachelor's,
```

```
!   5=Master's, 6=Dr,PhD)        (7th grade)
!parapsh  = parent academic push (7th grade)
!parcpsh  = parant college push  (7th grade)
!parmpsh  = parent math push     (7th grade)
!peerapsh = peer academic push   (7th grade)
!peermpsh = peer math push       (7th grade)

bas7 basse7 alg7 algse7 geo7 geose7
qlt7 qltse7 mth7 mthse7 mtha7 mthase7
bas8 basse8 alg8 algse8 geo8 geose8
qlt8 qltse8 mth8 mthse8 mtha8 mthase8
bas9 basse9 alg9 algse9 geo9 geose9
qlt9 qltse9 mth9 mthse9 mtha9 mthase9
bas10 basse10 alg10 algse10 geo10 geose10
qlt10 qltse10 mth10 mthse10 mtha10 mthase10
bas11 basse11 alg11 algse11 geo11 geose11
qlt11 qltse11 mth11 mthse11 mtha11 mthase11
bas12 basse12 alg12 algse12 geo12 geose12
qlt12 qltse12 mth12 mthse12 mtha12 mthase12
!bas7-bas12     = Basic math IRT scores
!basse7-12      = Basic math SE of IRT
!alg7-alg12     = Algebra IRT score
!algse7-12      = Algebra SE of IRT
!geo7-geo12     = Geometry IRT score
!geose7-geose12 = Geometry SE of IRT
!qlt7-qlt12     = Quantitative Literacy IRT
!qltse7-qltse12 = Quantitative Literacy SE of IRT
!mth7-mth12     = Aggregate math IRT, w/o aberrants
!mthse7-mthse12 = Aggreagte math IRT, w/o aberrrants
!mtha7-matha12  = Aggregate math IRT, w/ aberrants
!mtha7-mtha12   = Aggregate math SE of IRT, w/
!                 aberrants

mthcrs7-mthcrs12 mtrk10-mtrk12
!mthcrs7-mthcrs12 = Highest math course taken
!                   during each grade
! (0 = no course,
!    1 = low,basic,  2 = average,
!    3 = high,       4 = pre-algebra,
!  5 = algebra I,  6 = geometry,
!  7 = algebra II, 8 = pre-calc,
!    9 = calculus)
!
!mtrk10-mtrk12 = Highest math course taken through
!                grades 10-12
! (1 = low,
!    2 = algebra I,
!    3 = algebra I & II,
!  4 = algebra and geometry,
!    5 = algebra I, II, and geometry,
!  6 = pre-calc,
!    7 = calculus)

totstud
lchfull lchpart parvis
```

```
!totstud = total # of students
!          (9th)
!
!lchfull = % of student eligible for full lunch
!          assitance
!          (9th)
!lchpart = % of student eligible for partial
!          lunch assitance
!          (9th)
!parvis  = % of parents that visit the school
!          (9th)

mcirr mclub strat mstrat comp mcomp
!Mcirr = school provides math curriculum guide
!        (1=yes, 2=no)
!        (9th)
!Mclub = school has math club
!        (1=yes, 2=no)
!        (9th)
!STrat = ratio of student to Full Time teachers
!        (9th)
!MSTrat= ratio of students to Full Time Math
!        teachers
!        (9th)
!comp  = ratio of students to computers for
!        instructional use
!        (9th)
!Mcomp = ratio of students to computers for
!        math instruction use
!        (9th)

african hispan asian
!african = percent of african american students
!          (9th)
!hispan  = percent of hispanic students
!          (9th)
!asian   = percent of asian students
!          (9th)

expel arrest dropot
!expel  = Ever been expelled from school
!         (0=no, 1=yes)
!       (used in PROBLEM VAR)
!         (7th Grd)
!arrest = Ever been arrested
!         (0=no, 1=yes)
!         (used in PROBLEM VAR)
!         (7th grd)
!dropot = Have you EVER thought about dropping out
!         (0=no, 1=yes)
!         (used in PROBLEM VAR)
!         (7th grd)

self worth other
!self = positive attitute toward self
```

```
!         (1=strongly agree, 2=agree,
!    3=not sure, 4=disagree,
!          5=strongly disagree)
!         (7th Grd)
!worth = person of worth
!         (1=strongly agree, 2=agree,
!          3=not sure, 4=disagree,
!          5=strongly disagree)
!         (7th Grd)
!other = able to do things as well as others
!         (1=strongly agree, 2=agree,
!          3=not sure, 4=disagree,
!          5=strongly disagree)
!         (7th grd)

satisf respect failure esteem problem cloctn
!satisf = generally satisfied w/self
!         (1=strongly agree, 2=agree,
!    3=not sure, 4=disagree,
!          5=strongly disagree)
!         (7th Grd)
!respect = wish I respected myself more
!         (1=strongly agree, 2=agree,
!    3=not sure, 4=disagree,
!          5=strongly disagree)
!         (7th Grd)
!failure = feel I am a failure
!         (1=strongly agree, 2=agree,
!        3=not sure, 4=disagree,
!          5=strongly disagree)
!         (7th Grd)
!esteem = average of self, worth, other, satisf,
!         respect, failure
!problem = 1 if (expel=1 or arrest=1 or dropot=1),
!          0 otherwise
!          (7th Grd)
!cloctn = Fall 88 respondent location
!         (1=In orginal School,
!          2=Moved another school,
!        3=moved, not located,
!          4=dropped out of school,
!        5=early graduation,
!          6=Quit Study)

dloctn eloctn floctn gloctn hloctn iloctn jloctn
kloctn lloctn
!dloctn = Spring 89 respondent location
!eloctn = Fall 89 respondent location
!floctn = Spring 90 respondent location
!gloctn = Fall 90 respondent location
!hloctn = spring 91 respondent location
!iloctn = fall 91 respondent location
!jloctn = spring 92 respondent location
!kloctn = fall 92 respondent location
!lloctn = spring 93 respondent location
```

```
    drink runawa suicid alc7 alc10 alc11 alc12
    !drink  = "Have you ever taken a drink alcohol"
    !         (7th grade)
    !runawa = "Have you ever thought about running
    !          away"
    !         (7th grade)
    !suicid = "Have you ever considered suicide"
    !         (7th grade)
    !alc7   = "Last summer, I had 6+ drinks."
    !         (7th grade)
    !alc10-12 = "Last summer, I had 6+ drinks."

    arest7
    runa8 runa9 runa10 runa11 run12
    suic8 suic9 suic10 suic11 suic12
    drop7 drop8 drop9 drop10 drop11 drop12
    fdrop8 fdrop9 fdrop10 fdrop11 fdrop12
    !arest7    = "Last summer, I was picked up
    !             and arrested"
    !             (7th grade)
    !runa8-12  = "Last summer, I thought about
    !             running away"
    !            (Asked in Fall)
    !suic8-12  = "Last summer, I considered suicide"
    !            (Asked in FALL)
    !drop7-12 = "This school yr, thought seriously
    !            about dropping out."
    !            (Asked in Spring)
    !fdrop8-12 = "How many of your friends will
    !             drop out before graduating
    !             from high school"

    enj7 good7 und7 useboy7 nerv7 wor7
    scar7 use7 logic7 boybet7 job7 often7
    enj8 good8 und8 useboy8 nerv8 wor8
    scar8 use8 logic8 boybet8 job8 often8
    enj9 good9 und9 useboy9 nerv9 wor9
    scar9 use9 logic9 boybet9 job9 often9
    enj10 good10 und10 useboy10 nerv10 wor10
    scar10 use10 logic10 boybet10 job10 often10;
    !enj7-10    = "I ENJOY MATH"
    !good7-10   = "I AM GOOD AT MATH"
    !und7-10    = "USUALLY UNDERSTAND MATH"
    !useboy7-10 = "MATH MORE USEFUL FOR BOYS"
    !nerv7-10   = "MATH MAKES ME NERVOUS"
    !wor7-10    = "WORRY ABOUT MATH TEST GRADES"
    !scar7-10   = "SCARED WHEN I OPEN MATH BOOK"
    !use7-10    = "MATH USEFUL IN EVERYDAY PROBLEMS"
    !logic7-10  = "MATH HELPS LOGICAL THINKING"
    !boybet7-10 = "BOYS BETTER AT MATH THAN GIRLS"
    !job7-10    = "NEED MATH FOR A GOOD JOB"
    !often7-10  = "WILL USE MATH OFTEN AS AN ADULT"
!
!
```

```
            ! End of Variable List
            !

         USEVAR= enj7 good7 und7 use7 job7 often7;
           ! enj8 good8 und8 use8 job8 often8;
           ! enj9 good9 und9 use9 job9 often9;
           ! enj10 good10 und10 use10 job10 often10;
           !
           ! This is a small subset of varables proposed to be
           ! examined in the assignment.
           !
           ! Due to the restrictions placed, the data has to be
           ! analyzed by grade.
           !
           ! The full set of variables proposed by the assignment
           ! (as listed below), can only be analyzed with the
           ! full version of Mplus.
           !
           !  enj7 good7 und7 useboy7 nerv7 wor7
           !  scar7 use7 logic7 boybet7 job7 often7
           !  enj8 good8 und8 useboy8 nerv8 wor8
           !  scar8 use8 logic8 boybet8 job8 often8
           !  enj9 good9 und9 useboy9 nerv9 wor9
           !  scar9 use9 logic9 boybet9 job9 often9
           !  enj10 good10 und10 useboy10 nerv10 wor10
           !  scar10 use10 logic10 boybet10 job10 often10;
         Missing are all(9999);

ANALYSIS: TYPE = basic missing;
           ! To obtain the descriptive statistics of the variables.
           !
           ! <Exploratory Factor Analysis>
           ! TYPE = EFA 1 3;
           ! ESTIMATOR = ML;
           !
           ! In the statements above,
           ! 1-, 2-, ..., and 3-factor solution are requested,
           ! using Maximum Likelihood estimator (if not specified,
           ! ULS estimator is used as default).
           !
           ! ML provides chi-square and RMSEA measures of goodens
           ! of fit.

PLOT: TYPE = plot1 plot2 plot3;
```

M*plus* Code: EFA within CFA (Orthogonal)

```
Title:
        This is a partial input file for HW1 that will now be used
        for HW2.  The variable names are for the data set lsay.dat.
        "EFA in a CFA(Orthogonal)" for Grade 7.

DATA:
        FILE IS C:\Ed.231E\Assignment_02\lsay.dat;

VARIABLE:
            Names are lsayid schcode classize urban tracking ntracks
              mthlvl female mthflg7-mthflg12 mothed fathed mothsei
              fathsei homeres race
              expect parapsh parcpsh parmpsh peerapsh peermpsh
              bas7 basse7 alg7 algse7 geo7 geose7
              qlt7 qltse7 mth7 mthse7 mtha7 mthase7
              bas8 basse8 alg8 algse8 geo8 geose8
              qlt8 qltse8 mth8 mthse8 mtha8 mthase8
              bas9 basse9 alg9 algse9 geo9 geose9
              qlt9 qltse9 mth9 mthse9 mtha9 mthase9
              bas10 basse10 alg10 algse10 geo10 geose10
              qlt10 qltse10 mth10 mthse10 mtha10 mthase10
              bas11 basse11 alg11 algse11 geo11 geose11
              qlt11 qltse11 mth11 mthse11 mtha11 mthase11
              bas12 basse12 alg12 algse12 geo12 geose12
              qlt12 qltse12 mth12 mthse12 mtha12 mthase12
              mthcrs7-mthcrs12 mtrk10-mtrk12 totstud lchfull
              lchpart parvis mcirr mclub strat mstrat comp mcomp
              african hispan asian expel arrest dropot self worth
              other satisf respect failure esteem problem cloctn
              dloctn eloctn floctn gloctn hloctn iloctn jloctn
              kloctn lloctn drink runawa suicid alc7 alc10 alc11
              alc12 arest7 runa8 runa9 runa10 runa11 run12 suic8
              suic9 suic10 suic11 suic12 drop7 drop8 drop9 drop10
              drop11 drop12 fdrop8 fdrop9 fdrop10 fdrop11 fdrop12
              enj7 good7 und7 useboy7 nerv7 wor7 scar7 use7 logic7
              boybet7 job7 often7 enj8 good8 und8 useboy8 nerv8
              wor8 scar8 use8 logic8 boybet8 job8 often8 enj9
              good9 und9 useboy9 nerv9 wor9 scar9 use9 logic9
              boybet9 job9 often9 enj10 good10 und10 useboy10
              nerv10 wor10 scar10 use10 logic10 boybet10 job10
              often10;

        USEVAR= enj7 good7 und7 use7 job7 often7;
```

```
          ! enj8 good8 und8 use8 job8 often8;
          ! enj9 good9 und9 use9 job9 often9;
          ! enj10 good10 und10 use10 job10 often10;
          !
          ! This is a small subset of varables proposed to be
          ! examined in the assignment.
          !
          ! Due to the restrictions placed, the data has to be
          ! analyzed by grade.
          !
          ! The full set of variables proposed by the assignment
          ! (as listed below), can only be analyzed with the
          ! full version of Mplus.
          !
          !  enj7 good7 und7 useboy7 nerv7 wor7
          !  scar7 use7 logic7 boybet7 job7 often7
          !  enj8 good8 und8 useboy8 nerv8 wor8
          !  scar8 use8 logic8 boybet8 job8 often8
          !  enj9 good9 und9 useboy9 nerv9 wor9
          !  scar9 use9 logic9 boybet9 job9 often9
          !  enj10 good10 und10 useboy10 nerv10 wor10
          !  scar10 use10 logic10 boybet10 job10 often10;
        Missing are all(9999);

ANALYSIS:
          TYPE=general;
          ESTIMATOR = ML;
          !
          ! TYPE=general is the default, unless specified to be
          ! otherwise.
          !
          ! GENERAL deals with all models containing relationships
          ! among continuous and categorical oberved/latent
          ! variables.
          !
          ! Models covered include: Linear Regression, Probit
          ! Regression, Path Analysis, CFA, SEM, Multilevel
          ! Modeling, Growth Modeling, General Mixture Modeling.
          !
          ! Using Maximum Likelihood estimator (if not specified,
          ! ULS estimator is used as default).
          !
          ! ML provides chi-square and RMSEA measures of goodens
          ! of fit.

MODEL:
        attitude BY enj7-often7*    often7@0;
        ! The factor "Positive Atitude towards Math" is measured
        ! BY three manifest variables: "enj," "good," and "und."
        !
        ! Based on the factor loadings obtained from EFA,
        ! variable "good," with factor loading close to "1" on
        ! factor "attitude" and low loading on factor "necessit"
        ! is chosen to be the anchor item.
        !
```

```
        ! Since the solution is orthogonal, variace for the two
        ! factors are set to zero, and the covariance between
        ! the two factors are set to be zero (as specified below).
        ! This additional anhor item alone, will play the role of
        ! fixing the rotation
        !
        ! The anchor item for the factor "necessit" will be
        ! fixed at "0."
        !
        ! The "*" indicates that the parameters are
        ! freely estimated.

        necessit BY enj7-often7*;
        ! The factor "Necessity of Math" is measured
        ! BY three manifest variables: "use," "job," and "often."
        ! The "*" indicates that the parameters are
        ! freely estimated.

        attitude-necessit@1;
        ! To estimate the factor loadings and be able to compare
        ! the values, the variance of each factor is fixed at
        ! ("@") "1."
        !
        ! This is a default under "TYPE=EFA # #"

        attitude with necessit@0;
        ! Since this is an Orthogonal "EFA in a CFA," we are
        ! fixing the covariance between the two factors to "0."

OUTPUT:
        Standardized Modindices(3.84) FSDeterminacy;
        ! Standardized ... produces standardized coefficients .
        !
        ! Modindices ... produced modification indeces with
        !                the minimum expected drop in the
        !                chi-squre given in the paranthesis.
        !
        !                While some use (0), others put donw
        !                (3.84) which would exclue those drops
        !                that are non-significant.
        !
        ! FSDeterminacy...produces Factor Score Determinacies.
        !                 FSDeterminacy indicates how close
        !                 the average estimate factor scores
        !                 are to true factor scores.
        !
        !                 In general, it is desirable to have
        !                 values that are .80 or higher.
        !

PLOT:
        TYPE = plot1 plot2 plot3;
        ! Plot 2 if for the scree plot.
```

M*plus* Code: EFA within CFA (Oblique)

```
Title:
        This is a partial input file for HW1 that will now be used
        for HW2.  The variable names are for the data set lsay.dat.
        "EFA in a CFA(Oblique)" for Grade 7.

DATA:
        FILE IS C:\Ed.231E\Assignment_02\lsay.dat;

VARIABLE:
            Names are lsayid schcode classize urban tracking ntracks
              mthlvl female mthflg7-mthflg12 mothed fathed mothsei
              fathsei homeres race
              expect parapsh parcpsh parmpsh peerapsh peermpsh
              bas7 basse7 alg7 algse7 geo7 geose7
              qlt7 qltse7 mth7 mthse7 mtha7 mthase7
              bas8 basse8 alg8 algse8 geo8 geose8
              qlt8 qltse8 mth8 mthse8 mtha8 mthase8
              bas9 basse9 alg9 algse9 geo9 geose9
              qlt9 qltse9 mth9 mthse9 mtha9 mthase9
              bas10 basse10 alg10 algse10 geo10 geose10
              qlt10 qltse10 mth10 mthse10 mtha10 mthase10
              bas11 basse11 alg11 algse11 geo11 geose11
              qlt11 qltse11 mth11 mthse11 mtha11 mthase11
              bas12 basse12 alg12 algse12 geo12 geose12
              qlt12 qltse12 mth12 mthse12 mtha12 mthase12
              mthcrs7-mthcrs12 mtrk10-mtrk12 totstud lchfull
              lchpart parvis mcirr mclub strat mstrat comp mcomp
              african hispan asian expel arrest dropot self worth
              other satisf respect failure esteem problem cloctn
              dloctn eloctn floctn gloctn hloctn iloctn jloctn
              kloctn lloctn drink runawa suicid alc7 alc10 alc11
              alc12 arest7 runa8 runa9 runa10 runa11 run12 suic8
              suic9 suic10 suic11 suic12 drop7 drop8 drop9 drop10
              drop11 drop12 fdrop8 fdrop9 fdrop10 fdrop11 fdrop12
              enj7 good7 und7 useboy7 nerv7 wor7 scar7 use7 logic7
              boybet7 job7 often7 enj8 good8 und8 useboy8 nerv8
              wor8 scar8 use8 logic8 boybet8 job8 often8 enj9
              good9 und9 useboy9 nerv9 wor9 scar9 use9 logic9
              boybet9 job9 often9 enj10 good10 und10 useboy10
              nerv10 wor10 scar10 use10 logic10 boybet10 job10
              often10;

        USEVAR= enj7 good7 und7 use7 job7 often7;
```

```
          ! enj8 good8 und8 use8 job8 often8;
          ! enj9 good9 und9 use9 job9 often9;
          ! enj10 good10 und10 use10 job10 often10;
          !
          ! This is a small subset of varables proposed to be
          ! examined in the assignment.
          !
          ! Due to the restrictions placed, the data has to be
          ! analyzed by grade.
          !
          ! The full set of variables proposed by the assignment
          ! (as listed below), can only be analyzed with the
          ! full version of Mplus.
          !
          !  enj7 good7 und7 useboy7 nerv7 wor7
          !  scar7 use7 logic7 boybet7 job7 often7
          !  enj8 good8 und8 useboy8 nerv8 wor8
          !  scar8 use8 logic8 boybet8 job8 often8
          !  enj9 good9 und9 useboy9 nerv9 wor9
          !  scar9 use9 logic9 boybet9 job9 often9
          !  enj10 good10 und10 useboy10 nerv10 wor10
          !  scar10 use10 logic10 boybet10 job10 often10;
        Missing are all(9999);

ANALYSIS:
          TYPE=general;
          ESTIMATOR = ML;
          !
          ! TYPE=general is the default, unless specified to be
          ! otherwise.
          !
          ! GENERAL deals with all models containing relationships
          ! among continuous and categorical oberved/latent
          ! variables.
          !
          ! Models covered include: Linear Regression, Probit
          ! Regression, Path Analysis, CFA, SEM, Multilevel
          ! Modeling, Growth Modeling, General Mixture Modeling.
          !
          ! Using Maximum Likelihood estimator (if not specified,
          ! ULS estimator is used as default).
          !
          ! ML provides chi-square and RMSEA measures of goodens
          ! of fit.

MODEL:
        attitude BY enj7-often7*    often7@0;
        ! The factor "Positive Atitude towards Math" is measured
        ! BY three manifest variables: "enj," "good," and "und."
        !
        ! Based on the factor loadings obtained from EFA,
        ! variable "good," with factor loading close to "1" on
        ! factor "attitude" and low loading on factor "necessit"
        ! is chosen to be the anchor item.
        !
```

```
        ! The anchor item for the factor "necessit" will be
        ! fixed at "0."
        !
        ! The "*" indicates that the parameters are
        ! freely estimated.

        necessit BY enj7-often7*    good7@0;
        ! The factor "Necessity of Math" is measured
        ! BY three manifest variables: "use," "job," and "often."
        !
        ! Based on the factor loadings obtained from EFA,
        ! variable "often," with factor loading close to "1" on
        ! factor "necessit" and low loading on factor "attitude"
        ! is chosen to be the anchor item.
        !
        ! The anchor item for the factor "attitude" will be
        ! fixed at "0."
        !
        ! The "*" indicates that the parameters are
        ! freely estimated.

        attitude-necessit@1;
        ! To estimate the factor loadings and be able to compare
        ! the values, the variance of each factor is fixed at
        ! ("@") "1."
        !
        ! This is a default under "TYPE=EFA # #"

        attitude with necessit*;
        ! The covariance between the two factors is freely estimated,
        ! since it is an oblique rotation.

OUTPUT:
        Standardized Modindices(3.84) FSDeterminacy;
        ! Standardized ... produces standardized coefficients .
        !
        ! Modindices ... produced modification indeces with
        !                the minimum expected drop in the
        !                chi-squre given in the paranthesis.
        !
        !                While some use (0), others put donw
        !                (3.84) which would exclue those drops
        !                that are non-significant.
        !
        ! FSDeterminacy...produces Factor Score Determinacies.
        !                 FSDeterminacy indicates how close
        !                 the average estimate factor scores
        !                 are to true factor scores.
        !
        !                 In general, it is desirable to have
        !                 values that are .80 or higher.
        !

PLOT:
        TYPE = plot1 plot2 plot3;
```

```
! Plot 2 if for the scree plot.
```

M*plus* Code: CFA

```
Title:
        This is a partial input file for HW1 that will now be used
        for HW2.  The variable names are for the data set lsay.dat.
        "CFA" for Grade 7.

DATA:
        FILE IS C:\Ed.231E\Assignment_02\lsay.dat;

VARIABLE:
            Names are lsayid schcode classize urban tracking ntracks
              mthlvl female mthflg7-mthflg12 mothed fathed mothsei
              fathsei homeres race
              expect parapsh parcpsh parmpsh peerapsh peermpsh
              bas7 basse7 alg7 algse7 geo7 geose7
              qlt7 qltse7 mth7 mthse7 mtha7 mthase7
              bas8 basse8 alg8 algse8 geo8 geose8
              qlt8 qltse8 mth8 mthse8 mtha8 mthase8
              bas9 basse9 alg9 algse9 geo9 geose9
              qlt9 qltse9 mth9 mthse9 mtha9 mthase9
              bas10 basse10 alg10 algse10 geo10 geose10
              qlt10 qltse10 mth10 mthse10 mtha10 mthase10
              bas11 basse11 alg11 algse11 geo11 geose11
              qlt11 qltse11 mth11 mthse11 mtha11 mthase11
              bas12 basse12 alg12 algse12 geo12 geose12
              qlt12 qltse12 mth12 mthse12 mtha12 mthase12
              mthcrs7-mthcrs12 mtrk10-mtrk12 totstud lchfull
              lchpart parvis mcirr mclub strat mstrat comp mcomp
              african hispan asian expel arrest dropot self worth
              other satisf respect failure esteem problem cloctn
              dloctn eloctn floctn gloctn hloctn iloctn jloctn
              kloctn lloctn drink runawa suicid alc7 alc10 alc11
              alc12 arest7 runa8 runa9 runa10 runa11 run12 suic8
              suic9 suic10 suic11 suic12 drop7 drop8 drop9 drop10
              drop11 drop12 fdrop8 fdrop9 fdrop10 fdrop11 fdrop12
              enj7 good7 und7 useboy7 nerv7 wor7 scar7 use7 logic7
              boybet7 job7 often7 enj8 good8 und8 useboy8 nerv8
              wor8 scar8 use8 logic8 boybet8 job8 often8 enj9
              good9 und9 useboy9 nerv9 wor9 scar9 use9 logic9
              boybet9 job9 often9 enj10 good10 und10 useboy10
              nerv10 wor10 scar10 use10 logic10 boybet10 job10
              often10;

        USEVAR= enj7 good7 und7 use7 job7 often7;
```

```
          ! enj8 good8 und8 use8 job8 often8;
          ! enj9 good9 und9 use9 job9 often9;
          ! enj10 good10 und10 use10 job10 often10;
          !
          ! This is a small subset of varables proposed to be
          ! examined in the assignment.
          !
          ! Due to the restrictions placed, the data has to be
          ! analyzed by grade.
          !
          ! The full set of variables proposed by the assignment
          ! (as listed below), can only be analyzed with the
          ! full version of Mplus.
          !
          !  enj7 good7 und7 useboy7 nerv7 wor7
          !  scar7 use7 logic7 boybet7 job7 often7
          !  enj8 good8 und8 useboy8 nerv8 wor8
          !  scar8 use8 logic8 boybet8 job8 often8
          !  enj9 good9 und9 useboy9 nerv9 wor9
          !  scar9 use9 logic9 boybet9 job9 often9
          !  enj10 good10 und10 useboy10 nerv10 wor10
          !  scar10 use10 logic10 boybet10 job10 often10;
        Missing are all(9999);

ANALYSIS:
          TYPE=general;
          ESTIMATOR = ML;
          !
          ! TYPE=general is the default, unless specified to be
          ! otherwise.
          !
          ! GENERAL deals with all models containing relationships
          ! among continuous and categorical oberved/latent
          ! variables.
          !
          ! Models covered include: Linear Regression, Probit
          ! Regression, Path Analysis, CFA, SEM, Multilevel
          ! Modeling, Growth Modeling, General Mixture Modeling.
          !
          ! Using Maximum Likelihood estimator (if not specified,
          ! ULS estimator is used as default).
          !
          ! ML provides chi-square and RMSEA measures of goodens
          ! of fit.

MODEL:
        attitude BY enj7-und7*;
        ! The factor "Positive Atitude towards Math" is measured
        ! BY three manifest variables: "enj," "good," and "und."
        !
        ! The anchor item is no longer necessary, unlike under
        ! "EFA in a CFA" setting.
        !
        ! The "*" indicates that the parameters are
        ! freely estimated.
```

```
        necessit BY use7-often7*;
        ! The factor "Necessity of Math" is measured
        ! BY three manifest variables: "use," "job," and "often."
        !
        ! The anchor item is no longer necessary, unlike under
        ! "EFA in a CFA" setting.
        !
        ! The "*" indicates that the parameters are
        ! freely estimated.

        attitude-necessit@1;
        ! To estimate the factor loadings and be able to compare
        ! the values, the variance of each factor is fixed at
        ! ("@") "1."
        !
        ! This is a default under "TYPE=EFA # #"

        attitude with necessit*;
        ! The covariance between the two factors is freely estimated.

OUTPUT:
        Standardized Modindices(3.84) FSDeterminacy;
        ! Standardized ... produces standardized coefficients .
        !
        ! Modindices ... produced modification indeces with
        !                the minimum expected drop in the
        !                chi-squre given in the paranthesis.
        !
        !                While some use (0), others put donw
        !                (3.84) which would exclue those drops
        !                that are non-significant.
        !
        ! FSDeterminacy...produces Factor Score Determinacies.
        !                 FSDeterminacy indicates how close
        !                 the average estimate factor scores
        !                 are to true factor scores.
        !
        !                 In general, it is desirable to have
        !                 values that are .80 or higher.
        !

PLOT:
        TYPE = plot1 plot2 plot3;
        ! Plot 2 if for the scree plot.
```