Comparing Groups: Continued

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Chapter 10

This chapter continues to compare groups but also attempts to show how to write results and discussion sections when using SEM (structural equation modeling). Included is a paper by Randhawa, Beamer, and Lundberg (1993) that will be used to demonstrate how the results might be written as well as possible problems with their analysis and discussion. Figure 1 demonstrates the proposed model. The authors present their "hypotheses" (the proposed model) on page 43 of the article. I personally would prefer a slightly more formal hypothesis but the method they used is one way to do it. Basically they plan to test whether self-efficacy is a mediating variable when predicting math achievement from math attitude scales. In addition they wonder whether this may be different for girls and boys. They seem to be hedging by not hypothesizing whether there will be a difference between boys and girls and more specifically what parts (or all) of the model will be different.

Note at the beginning of the results section they reported the outcome of the descriptive statistics. That paragraph is good except the last sentence is either not needed or there should be a rationale for the covariance matrix rather than indicating that everyone does it (i.e., Bentler indicates that a covariance is necessary when comparing models).

In the next paragraph the authors indicate that the model does not fit and by freeing a parameter it did fit. It seemed close to fitting to me. Also the new parameter was clearly based on getting the model to fit. I question the directionality of the parameter (see below). The lingo is good. The next paragraph ("We examined....") offers their justification for the new parameter -- completely taking advantage of chance. If you do then its good to be open about it. In that same paragraph they do a good job of indicating that they compared the two covariance matrices. In the next two paragraphs they do a good job of explaining their univariate statistics. The following is a jobstream for comparing the two covariance matrices (the correlation matrices are converted to covariance matrices by adding the standard deviations in the jobstream).

```
FILE NAME = MATHGB5.EQS

/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=108; var=7; me=ml;   mat=cor;
    groups=2;
/STA
 24.5 23.3 22.2 4.7 14.0 10.0 9.4
/labels
  v1=daily;     v2=courses;     v3=problems;     v4=mat;
  v5=alg;       v6=att1;        v7=att2;
/equ
```

```
 v6=   *f6    +  e6;
 v7=   *f7    + e7;
 v1=   *f1    + e1;
 v2=   *f2    + e2;
 v3=   *f3    + e3;
 v4=   *f4    + e4;
 v5=   *f5    + e5;
/var
   f1 to f7 =1;
/mat
1.00
 .59 1.00
 .69  .68 1.00
 .24  .38  .29 1.00
 .23  .54  .42  .58 1.00
 .38  .43  .44  .20  .48 1.00
 .35  .52  .47  .32  .61  .81 1.00
/cov
f1,f2=*;
f1,f3=*;
f1,f4=*;
f1,f5=*;
f1,f6=*;
f1,f7=*;
f2,f3=*;
f2,f4=*;
f2,f5=*;
f2,f6=*;
f2,f7=*;
f3,f4=*;
f3,f5=*;
f3,f6=*;
f3,f7=*;
f4,f5=*;
f4,f6=*;
f4,f7=*;
f5,f6=*;
f5,f7=*;
f6,f7=*;
/end
/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
```

```
/spe
    case=117; var=7; me=ml;  mat=cor;
    groups=2;
/lmtest
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/STA
 20.7 20.8 20.4 5.9 15.4 8.9 9.1
/equ
 v6=   *f6    +  e6;
 v7=   *f7    + e7;
 v1=   *f1    + e1;
 v2=   *f2    + e2;
 v3=   *f3    + e3;
 v4=   *f4    + e4;
 v5=   *f5    + e5;
/var
   f1 to f7 =1;
/mat
1.00
 .65 1.00
 .70  .72 1.00
 .18  .37  .44 1.00
 .22  .47  .48  .65 1.00
 .37  .54  .46  .35  .49 1.00
 .38  .55  .53  .43  .55  .74 1.00
/cov
f1,f2=*;
f1,f3=*;
f1,f4=*;
f1,f5=*;
f1,f6=*;
f1,f7=*;
f2,f3=*;
f2,f4=*;
f2,f5=*;
f2,f6=*;
f2,f7=*;
f3,f4=*;
f3,f5=*;
f3,f6=*;
f3,f7=*;
f4,f5=*;
```

```
f4,f6=*;
f4,f7=*;
f5,f6=*;
f5,f7=*;
f6,f7=*;
/con
(1,f1,f2)=(2,f1,f2);
(1,f1,f3)=(2,f1,f3);
(1,f1,f4)=(2,f1,f4);
(1,f1,f5)=(2,f1,f5);
(1,f1,f6)=(2,f1,f6);
(1,f1,f7)=(2,f1,f7);
(1,f2,f3)=(2,f2,f3);
(1,f2,f4)=(2,f2,f4);
(1,f2,f5)=(2,f2,f5);
(1,f2,f6)=(2,f2,f6);
(1,f2,f7)=(2,f2,f7);
(1,f3,f4)=(2,f3,f4);
(1,f3,f5)=(2,f3,f5);
(1,f3,f6)=(2,f3,f6);
(1,f3,f7)=(2,f3,f7);
(1,f4,f5)=(2,f4,f5);
(1,f4,f6)=(2,f4,f6);
(1,f4,f7)=(2,f4,f7);
(1,f5,f6)=(2,f5,f6);
(1,f5,f7)=(2,f5,f7);
(1,f6,f7)=(2,f6,f7);
/end
```

Only partial results of this run are presented:

```
GOODNESS OF FIT SUMMARY

INDEPENDENCE MODEL CHI-SQUARE =       865.166 ON     42 DEGREES OF FREEDOM

INDEPENDENCE AIC =   781.16580   INDEPENDENCE CAIC =   595.68959
       MODEL AIC =    -3.41326          MODEL CAIC =   -34.32597

CHI-SQUARE =       10.587 BASED ON      7 DEGREES OF FREEDOM
PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS     0.15769

BENTLER-BONETT NORMED    FIT INDEX=       0.988
```

BENTLER-BONETT NONNORMED FIT INDEX= 0.974
COMPARATIVE FIT INDEX = 0.996

LAGRANGE MULTIPLIER TEST (FOR RELEASING CONSTRAINTS)

CONSTRAINTS TO BE RELEASED ARE:

CONSTRAINTS FROM GROUP 2

```
CONSTR:  1  (1,F1,F2)-(2,F1,F2)=0;
CONSTR:  2  (1,F1,F3)-(2,F1,F3)=0;
CONSTR:  3  (1,F1,F4)-(2,F1,F4)=0;
CONSTR:  4  (1,F1,F5)-(2,F1,F5)=0;
CONSTR:  5  (1,F1,F6)-(2,F1,F6)=0;
CONSTR:  6  (1,F1,F7)-(2,F1,F7)=0;
CONSTR:  7  (1,F2,F3)-(2,F2,F3)=0;
CONSTR:  8  (1,F2,F4)-(2,F2,F4)=0;
CONSTR:  9  (1,F2,F5)-(2,F2,F5)=0;
CONSTR: 10  (1,F2,F6)-(2,F2,F6)=0;
CONSTR: 11  (1,F2,F7)-(2,F2,F7)=0;
CONSTR: 12  (1,F3,F4)-(2,F3,F4)=0;
CONSTR: 13  (1,F3,F5)-(2,F3,F5)=0;
CONSTR: 14  (1,F3,F6)-(2,F3,F6)=0;
CONSTR: 15  (1,F3,F7)-(2,F3,F7)=0;
CONSTR: 16  (1,F4,F5)-(2,F4,F5)=0;
CONSTR: 17  (1,F4,F6)-(2,F4,F6)=0;
CONSTR: 18  (1,F4,F7)-(2,F4,F7)=0;
CONSTR: 19  (1,F5,F6)-(2,F5,F6)=0;
CONSTR: 20  (1,F5,F7)-(2,F5,F7)=0;
CONSTR: 21  (1,F6,F7)-(2,F6,F7)=0;
```

UNIVARIATE TEST STATISTICS:

NO	CONSTRAINT	CHI-SQUARE	PROBABILITY
1	CONSTR: 1	0.848	0.357
2	CONSTR: 2	0.147	0.702
3	CONSTR: 3	1.903	0.168
4	CONSTR: 4	0.045	0.833
5	CONSTR: 5	0.516	0.472

6	CONSTR: 6	0.327	0.568
7	CONSTR: 7	0.635	0.426
8	CONSTR: 8	0.498	0.480
9	CONSTR: 9	0.304	0.581
10	CONSTR: 10	2.678	0.102
11	CONSTR: 11	0.421	0.517
12	CONSTR: 12	1.317	0.251
13	CONSTR: 13	0.335	0.563
14	CONSTR: 14	0.968	0.325
15	CONSTR: 15	0.339	0.560
16	CONSTR: 16	0.147	0.702
17	CONSTR: 17	0.544	0.461
18	CONSTR: 18	0.010	0.919
19	CONSTR: 19	0.004	0.947
20	CONSTR: 20	0.018	0.894
21	CONSTR: 21	0.677	0.411

Assessments using the LaGrange multiplier found none of the univariate or multivariate tests to be significant indicating that there were no differences between the covariance (correlation) matrices. The authors describe this a little awkwardly in the last two sentences of the third paragraph on page 44.

The description on page 44 starting "Path coefficients...." is good although I do not understand why they used the word "completely" in conjunction with the standardized solution. Their description of the goodness of fit is good. The description of the difference between boys and girls is slightly unclear in the text but it is clear in Table 4.

The added parameter to the model (thick arrow) in their Figure 1 is puzzling to me. First the direction is problematic for two reasons (1) all of their discussion implies the direction is from process to outcome (achievement) but here achievement seems to be affecting self-efficacy, and (2) the arrow actually makes the variable part of the factor rather than a path. I think that is not a path as indicated in the last paragraph on page 45 but one of the variables of the factor. The first full paragraph on page 46 does a good job of describing variance accounted for and the mediating variable.

I am not exactly sure what they did in the paragraph "It is possible..." I think they reversed the arrow between M-attitude and M-efficacy.

Even though I have criticized some of the results I think they did a good job of presenting complex information. However, the following runs cast some doubt on their interpretation. The following run tests the two models as originally proposed by the authors when the two genders are combined.

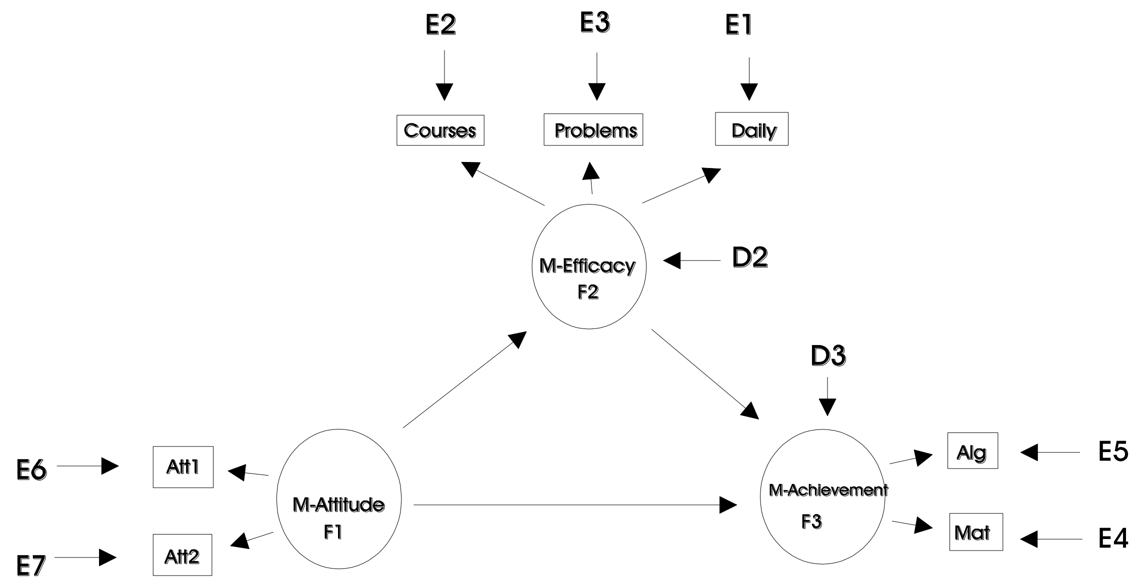


Figure 1. Proposed model.

MATHGB3.EQS

```
/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=255; var=7; me=ml;   mat=cor;
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/sta
 22.5  22.6  20.9  5.3  14.4  9.1  8.9
/lmtest
/tec
 itr=100
/equ
 v6=   *f1    +  e6;
 v7=   *f1    + e7;
 v1=   *f2    + e1;
 v2=   *f2    + e2;
 v3=   f2    + e3;
 v4=    f3    + e4;
 v5=   *f3    + e5;
 f2=   *f1    + d2;
```

```
 f3=   *f1   +  *f2   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
 .63 1.00
 .70  .71 1.00
 .24  .40  .37 1.00
 .21  .48  .44  .60 1.00
 .39  .48  .45  .30  .47 1.00
 .37  .53  .50  .39  .56  .77 1.00
/end
```

```
  GOODNESS OF FIT SUMMARY

  INDEPENDENCE MODEL CHI-SQUARE =        953.978 ON     21 DEGREES OF FREEDOM

  INDEPENDENCE AIC =   911.97777   INDEPENDENCE CAIC =   816.61123
         MODEL AIC =    21.69158          MODEL CAIC =   -28.26232

  CHI-SQUARE =        43.692 BASED ON     11 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS LESS THAN 0.001
  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS          41.660.

  BENTLER-BONETT NORMED     FIT INDEX=        0.954
  BENTLER-BONETT NONNORMED FIT INDEX=        0.933
  COMPARATIVE FIT INDEX              =        0.965


  STANDARDIZED SOLUTION:


 DAILY    =V1  =     .764*F2    +   .646 E1
 COURSES =V2  =     .826*F2    +   .564 E2
 PROBLEMS=V3  =     .882 F2    +   .471 E3
   MAT    =V4  =     .666 F3    +   .746 E4
   ALG    =V5  =     .901*F3    +   .433 E5
   ATT1   =V6  =     .821*F1    +   .571 E6
   ATT2   =V7  =     .938*F1    +   .347 E7
    F2    =F2  =     .619*F1    +   .785 D2
```

```
F3  =F3  =    .235*F2   +   .503*F1    +   .738 D3
```

```
STEP  PARAMETER   CHI-SQUARE  D.F.  PROBABILITY       CHI-SQUARE   PROBABILITY
---- -----------  ----------  ----  -----------       ----------   -----------

  1     V1,F3       25.657      1      0.000            25.657        0.000
```

It appears to me that the fit is not too bad. The next model follows the changes proposed by the authors. The next two jobstreams test the strength of the intervening factor of Mefficacy.

```
FILE NAME = MATHGB3A.EQS

/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=255; var=7; me=ml;  mat=cor;
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/sta
 22.5  22.6  20.9  5.3  14.4  9.1  8.9
/lmtest
/tec
 itr=100
/equ
 v6=   *f1    +  e6;
 v7=   *f1    + e7;
 v1=   f2    + e1;
 v2=   *f2    + e2;
 v3=   *f2    + e3;
 v4=    f3    + e4;
 v5=   *f3    + e5;
 f2=   *f1    + d2;
 f3=   *f2   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
```

```
 .63 1.00
 .70  .71 1.00
 .24  .40  .37 1.00
 .21  .48  .44  .60 1.00
 .39  .48  .45  .30  .47 1.00
 .37  .53  .50  .39  .56  .77 1.00
/end
```

```
  GOODNESS OF FIT SUMMARY

  INDEPENDENCE MODEL CHI-SQUARE =       953.978 ON    21 DEGREES OF FREEDOM

  INDEPENDENCE AIC =   911.97777   INDEPENDENCE CAIC =   816.61123
         MODEL AIC =    54.23226          MODEL CAIC =    -0.26290

  CHI-SQUARE =       78.232 BASED ON    12 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS LESS THAN 0.001
  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS          79.665.

  BENTLER-BONETT NORMED    FIT INDEX=       0.918
  BENTLER-BONETT NONNORMED FIT INDEX=       0.876
  COMPARATIVE FIT INDEX             =       0.929

  STANDARDIZED SOLUTION:

 DAILY   =V1  =    .746 F2    +   .666 E1
 COURSES =V2  =    .839*F2    +   .545 E2
 PROBLEMS=V3  =    .867*F2    +   .499 E3
  MAT    =V4  =    .711 F3    +   .703 E4
  ALG    =V5  =    .844*F3    +   .536 E5
  ATT1   =V6  =    .840*F1    +   .543 E6
  ATT2   =V7  =    .917*F1    +   .400 E7
   F2    =F2  =    .663*F1    +   .749 D2
   F3    =F3  =    .620*F2    +   .784 D3


  STEP  PARAMETER   CHI-SQUARE  D.F.  PROBABILITY       CHI-SQUARE  PROBABILITY
  ---- -----------  ----------  ----  -----------       ----------  -----------

    1     D3,D2        31.001     1      0.000             31.001       0.000
    2     V1,F3        53.006     2      0.000             22.005       0.000
    3     V1,F1        58.720     3      0.000              5.714       0.017
    4     V5,F1        64.116     4      0.000              5.397       0.020
```

FILE NAME = MATHGB3B.EQS

```
/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=255; var=7; me=ml;  mat=cor;
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/sta
 22.5  22.6  20.9  5.3  14.4  9.1  8.9
/lmtest
/tec
 itr=100
/equ
 v6=   *f1    +  e6;
 v7=   *f1    + e7;
 v1=   f2    + e1;
 v2=   *f2    + e2;
 v3=   *f2    + e3;
 v4=    f3    + e4;
 v5=   *f3    + e5;
 f2=   *f1    + d2;
 f3=   *f1   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
 .63 1.00
 .70  .71 1.00
 .24  .40  .37 1.00
 .21  .48  .44  .60 1.00
 .39  .48  .45  .30  .47 1.00
 .37  .53  .50  .39  .56  .77 1.00
/end
```

GOODNESS OF FIT SUMMARY

```
INDEPENDENCE MODEL CHI-SQUARE =        953.978 ON     21 DEGREES OF FREEDOM

INDEPENDENCE AIC =    911.97777    INDEPENDENCE CAIC =    816.61123
       MODEL AIC =     27.19591           MODEL CAIC =    -27.29925

CHI-SQUARE =        51.196 BASED ON     12 DEGREES OF FREEDOM
PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS LESS THAN 0.001
THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS          46.414.

BENTLER-BONETT NORMED    FIT INDEX=        0.946
BENTLER-BONETT NONNORMED FIT INDEX=        0.926
COMPARATIVE FIT INDEX              =        0.958



STANDARDIZED SOLUTION:
DAILY    =V1  =     .772 F2     +   .636 E1
COURSES =V2  =     .822*F2     +   .570 E2
PROBLEMS=V3  =     .880*F2     +   .475 E3
  MAT    =V4  =     .647 F3     +   .763 E4
  ALG    =V5  =     .928*F3     +   .373 E5
  ATT1   =V6  =     .829*F1     +   .560 E6
  ATT2   =V7  =     .923*F1     +   .385 E7
   F2    =F2  =    .639*F1     +   .770 D2
   F3    =F3  =    .653*F1     +   .758 D3

       CUMULATIVE MULTIVARIATE STATISTICS             UNIVARIATE INCREMENT
       ----------------------------------             --------------------

STEP   PARAMETER   CHI-SQUARE  D.F.  PROBABILITY      CHI-SQUARE  PROBABILITY
---- -----------  ----------  ----  -----------       ----------  -----------

  1     V1,F3       18.990      1      0.000            18.990       0.000
  2     F3,F2       30.938      2      0.000            11.948       0.001
  3     V4,F2       35.028      3      0.000             4.090       0.043
```

The R square and R square change can be computed as before. From model MATHGB3 the error for factor 3 was .545 (.738 * .738 for D3). Consequently, the R square was 1 - .545 or .455 with a multiple R of .787. When F2 to F3 was dropped leaving only F1 to F3 the relationship was: 1 - (.784 * .784) = 1 - .615 = .385 as R square and R = .620. When F1 to F3 was dropped leaving only F2 to F3 the relationship was: 1 - (.758 * 758) = 1 - .575 = .425 as R square and R = .65. Both factors account for about the same amount of variance. This difference can be tested. The following jobstream will test whether the difference is significant.

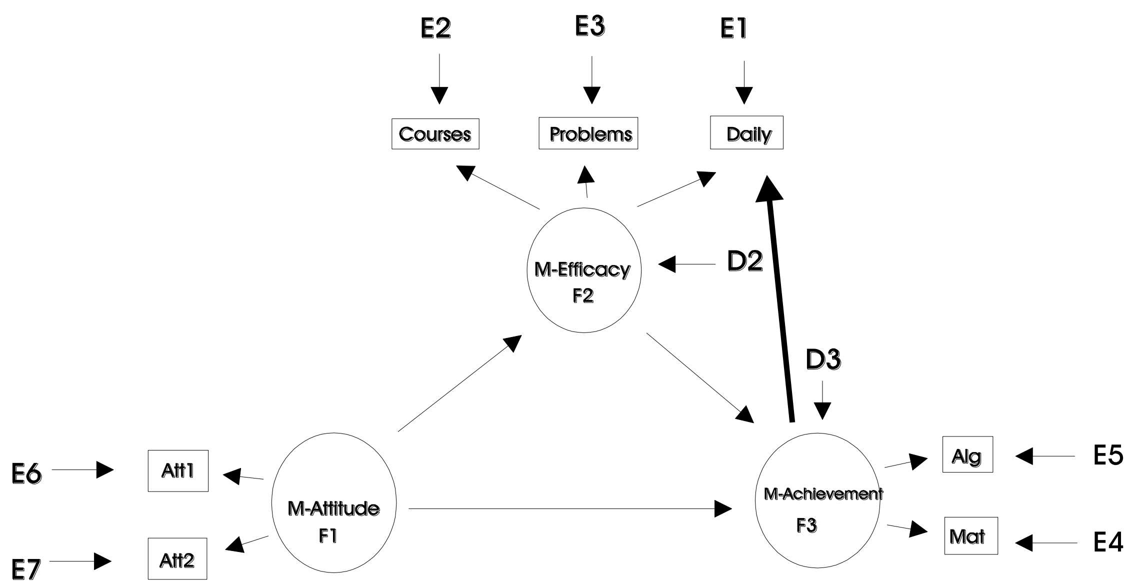
```
FILE NAME = MATHGB3C.EQS

/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=255; var=7; me=ml;  mat=cor;
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/sta
 22.5  22.6  20.9  5.3  14.4  9.1  8.9
/lmtest
/tec
 itr=100
/EQUATION
    V1  =   1.000 F2  +   1.000 E1   ;
    V2  =   1.034*F2  +   1.000 E2   ;
    V3  =   1.063*F2  +   1.000 E3   ;
    V4  =   1.000 F3  +   1.000 E4   ;
    V5  =   4.349*F3  +   1.000 E5   ;
    V6  =   8.384*F1  +   1.000 E6   ;
    V7  =   9.448*F1  +   1.000 E7   ;
    F2  =  10.495*F1  +   1.000 D2   ;
    F3  =    .043*F2  +   1.692*F1  +   1.000 D3   ;
/VARIANCES
       F1=    1.000  ;
       E1=  263.601* ;
       E2=  190.112* ;
       E3=  119.807* ;
       E4=   14.039* ;
       E5=   16.320* ;
       E6=   32.454* ;
       E7=    2.569* ;
       D2=  224.101* ;
       D3=    5.197* ;
/mat
1.00
 .63 1.00
 .70  .71 1.00
 .24  .40  .37 1.00
 .21  .48  .44  .60 1.00
```

```
 .39  .48  .45  .30  .47 1.00
 .37  .53  .50  .39  .56  .77 1.00
/con
(f3,f1)=(f3,f2);
/end
```

```
  GOODNESS OF FIT SUMMARY

  INDEPENDENCE MODEL CHI-SQUARE =        953.978 ON     21 DEGREES OF FREEDOM

  INDEPENDENCE AIC =   911.97777   INDEPENDENCE CAIC =   816.61123
         MODEL AIC =    50.13734          MODEL CAIC =    -4.35782

  CHI-SQUARE =       74.137 BASED ON     12 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS LESS THAN 0.001
  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS          75.957.

  BENTLER-BONETT NORMED    FIT INDEX=        0.922
  BENTLER-BONETT NONNORMED FIT INDEX=        0.883
  COMPARATIVE FIT INDEX              =        0.933



  STANDARDIZED SOLUTION:



 DAILY   =V1  =     .743 F2    +   .669 E1
 COURSES =V2  =     .838*F2    +   .545 E2
 PROBLEMS=V3  =     .867*F2    +   .498 E3
   MAT   =V4  =     .707 F3    +   .708 E4
   ALG   =V5  =     .849*F3    +   .529 E5
   ATT1  =V6  =     .836*F1    +   .549 E6
   ATT2  =V7  =     .921*F1    +   .391 E7
    F2   =F2  =     .657*F1    +   .754 D2
    F3   =F3  =     .605*F2    +   .036*F1    +   .777 D3

  LAGRANGE MULTIPLIER TEST (FOR RELEASING CONSTRAINTS)

  CONSTRAINTS TO BE RELEASED ARE:

         CONSTR:   1   (F3,F1)-(F3,F2)=0;
```

```
          UNIVARIATE TEST STATISTICS:

  NO    CONSTRAINT     CHI-SQUARE   PROBABILITY
  --    -----------   ----------   -----------

   1    CONSTR:   1        27.647        0.000
```

This p value less than .05 indicates that the two parameters are significantly different. That F1 has a stronger relationship to F3 than does F2.




```
FILE NAME = MATHGB4.EQS

/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=255; var=7; me=ml;  mat=cor;
/labels
```

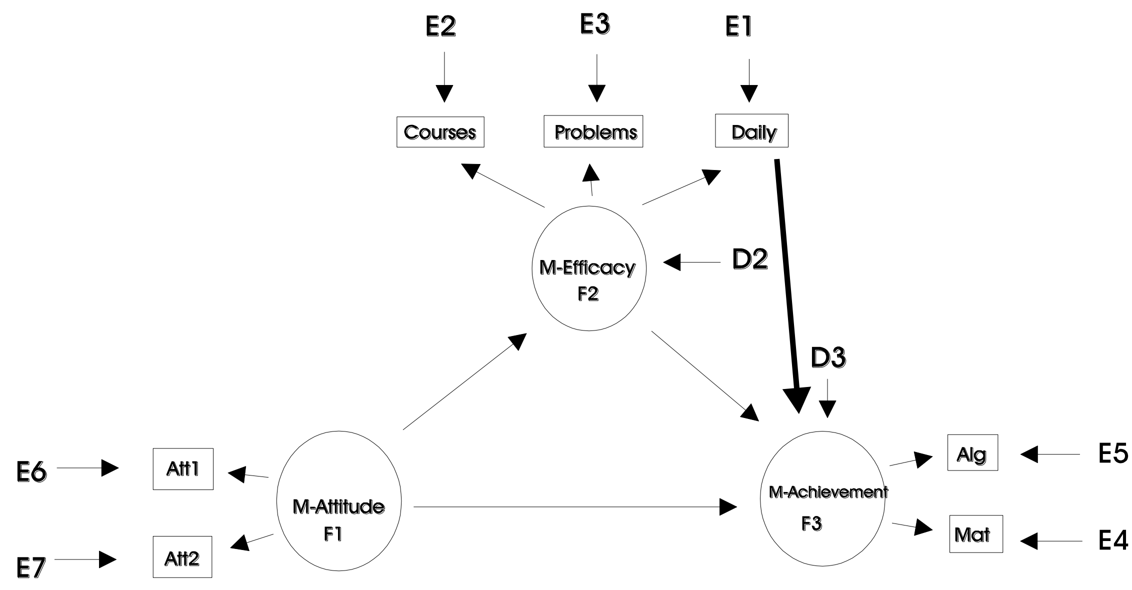
```
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/sta
 22.5  22.6  20.9  5.3  14.4  9.1  8.9
/lmtest
/equ
 v6=   *f1     +  e6;
 v7=   *f1     + e7;
 v1=   *f2  + *f3   + e1;
 v2=    f2     + e2;
 v3=   *f2     + e3;
 v4=    f3     + e4;
 v5=   *f3     + e5;
 f2=   *f1     + d2;
 f3=   *f1   +  *f2   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
 .63 1.00
 .70  .71 1.00
 .24  .40  .37 1.00
 .21  .48  .44  .60 1.00
 .39  .48  .45  .30  .47 1.00
 .37  .53  .50  .39  .56  .77 1.00
/end
```

```
  GOODNESS OF FIT SUMMARY

  INDEPENDENCE MODEL CHI-SQUARE =       953.978 ON    21 DEGREES OF FREEDOM

  INDEPENDENCE AIC =   911.97777   INDEPENDENCE CAIC =   816.61123
         MODEL AIC =    -5.69496          MODEL CAIC =   -51.10760

  CHI-SQUARE =       14.305 BASED ON    10 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS     0.15953
  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS        13.650.

  BENTLER-BONETT NORMED    FIT INDEX=       0.985
  BENTLER-BONETT NONNORMED FIT INDEX=       0.990
  COMPARATIVE FIT INDEX             =       0.995
```

STANDARDIZED SOLUTION:

```
DAILY    =V1  =    1.009*F2    +  -.363*F3    +   .540 E1
COURSES =V2  =      .827 F2    +   .563 E2
PROBLEMS=V3  =      .861*F2    +   .509 E3
  MAT    =V4  =     .653 F3    +   .757 E4
  ALG    =V5  =     .918*F3    +   .397 E5
  ATT1   =V6  =     .822*F1    +   .569 E6
  ATT2   =V7  =     .936*F1    +   .351 E7
   F2    =F2  =     .647*F1    +   .762 D2
   F3    =F3  =     .320*F2    +   .436*F1    +   .726 D3
```

This model fits better but it does not have a non-significant Chi-square as the model of the authors. But mostly this model does not make much sense. The authors indicate that the new parameter is a path "As shown in Figure 1 for the total group solution, the MSES daily subscale had a path coefficient of -.37." However, they correctly do not refer to it as a path in Table 4. Yet the manner in which it is drawn on Figure 1 and the above reference implies it is a "path" and therefore part of the structure rather than "measurement." It is in fact part of the factor 3 and factor 2, and therefore measurement and not structure. Even if we could imagine that it is structure it appears to be going in the wrong direction. The authors indicate that the factor M-efficacy influences achievement but now we have Achievement effecting one of the variables that makes up factor 2 which in turn influences factor 3. Both of these problems could be solved if the direction of the arrow was reversed. The arrow should go from variable 1 (daily) directly to the Achievement factor (F3). It would be a path and would influence in the direction that other parts of the discussion moves. The following is a jobstream that accomplishes that:



FILE NAME = MATHGB7.EQS

```
/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=255; var=7; me=ml;  mat=cor;
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/sta
 22.5  22.6  20.9  5.3  14.4  9.1  8.9
/lmtest
/tec
 itr=100
/equ
 v6=   *f1    +  e6;
 v7=   *f1    + e7;
 v1=   f2    + e1;
 v2=   *f2    + e2;
 v3=   *f2    + e3;
 v4=    f3    + e4;
```

```
 v5=   *f3     + e5;
 f2=   *f1     + d2;
 f3=   *f1  + *v1 +  *f2   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
 .63 1.00
 .70  .71 1.00
 .24  .40  .37 1.00
 .21  .48  .44  .60 1.00
 .39  .48  .45  .30  .47 1.00
 .37  .53  .50  .39  .56  .77 1.00
/end
```

```
  GOODNESS OF FIT SUMMARY

  INDEPENDENCE MODEL CHI-SQUARE =        953.978 ON     21 DEGREES OF FREEDOM

  INDEPENDENCE AIC =    911.97777   INDEPENDENCE CAIC =    816.61123
         MODEL AIC =      0.56393          MODEL CAIC =   -44.84871

  CHI-SQUARE =        20.564 BASED ON     10 DEGREES OF FREEDOM
  PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS      0.02435
  THE NORMAL THEORY RLS CHI-SQUARE FOR THIS ML SOLUTION IS           20.519.

  BENTLER-BONETT NORMED     FIT INDEX=        0.978
  BENTLER-BONETT NONNORMED FIT INDEX=        0.976
  COMPARATIVE FIT INDEX               =        0.989

  STANDARDIZED SOLUTION:

 DAILY    =V1  =      .775 F2     +   .632 E1
 COURSES =V2  =      .830*F2     +   .558 E2
 PROBLEMS=V3  =      .870*F2     +   .493 E3
   MAT    =V4  =      .647 F3     +   .763 E4
   ALG    =V5  =      .920*F3     +   .392 E5
   ATT1   =V6  =      .831*F1     +   .557 E6
   ATT2   =V7  =      .927*F1     +   .375 E7
    F2    =F2  =      .626*F1     +   .780 D2
    F3    =F3  =    -.486*V1     +   .726*F2     +   .398*F1     +   .672 D3
```

Notice that this model fits about as well as the model above with the arrow going in the opposite direction. The D3 indicates more variance accounted for in the Achievement factor .726 vs. .672. However, the Chi-square is larger indicating a poorer fit. The other fit indexes are essentially the same. This alternative model appears to fit about the same but make more logical sense. The next area to consider is the difference between girls and boys. As noted above there is no difference between the two correlation matrices. In the original proposed by the authors there is no difference between the two structural models.

```
FILE NAME = MATHGB1.EQS

/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=108; var=7; me=ml;  mat=cor;
    groups=2;
/STA
 24.5 23.3 22.2 4.7 14.0 10.0 9.4
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/lmtest
/tec
  itr=50
/equ
 v6=   *f1    +  e6;
 v7=   *f1    + e7;
 v1=   f2    + e1;
 v2=   *f2    + e2;
 v3=   *f2    + e3;
 v4=    f3    + e4;
 v5=   *f3    + e5;
 f2=   *f1    + d2;
 f3=   *f1   +  *f2   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
 .59 1.00
 .69  .68 1.00
 .24  .38  .29 1.00
```

```
 .23  .54  .42  .58 1.00
 .38  .43  .44  .20  .48 1.00
 .35  .52  .47  .32  .61  .81 1.00
/end
/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=117; var=7; me=ml;  mat=cor;
    groups=2;
/lmtest
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/STA
 20.7 20.8 20.4 5.9 15.4 8.9 9.1
/tec
  itr=50
/equ
 v6=   *f1    +  e6;
 v7=   *f1    + e7;
 v1=   f2    + e1;
 v2=   *f2    + e2;
 v3=   *f2    + e3;
 v4=    f3    + e4;
 v5=   *f3    + e5;
 f2=   *f1    + d2;
 f3=   *f1   +  *f2   + d3;
/var
   f1=1;d2=*;d3=*;
 e1=*; e2=*; e3=*; e4=*; e5=*; e6=*; e7=*;
/mat
1.00
 .65 1.00
 .70  .72 1.00
 .18  .37  .44 1.00
 .22  .47  .48  .65 1.00
 .37  .54  .46  .35  .49 1.00
 .38  .55  .53  .43  .55  .74 1.00
/con
(1,f2,f1)=(2,f2,f1);
(1,f3,f1)=(2,f3,f1);
(1,f3,f2)=(2,f3,f2);
```

```
/end
```

Only the Standardized Solution and Goodness of fit data is presented.

```
STANDARDIZED SOLUTION:


DAILY   =V1  =    .748 F2    +  .664 E1
COURSES =V2  =    .808*F2    +  .589 E2
PROBLEMS=V3  =    .871*F2    +  .491 E3
 MAT    =V4  =    .649 F3    +  .761 E4
 ALG    =V5  =    .960*F3    +  .279 E5
 ATT1   =V6  =    .827*F1    +  .562 E6
 ATT2   =V7  =    .986*F1    +  .167 E7
  F2    =F2  =    .574*F1    +  .819 D2
  F3    =F3  =    .247*F2    +  .529*F1    +  .713 D3


STANDARDIZED SOLUTION:

DAILY   =V1  =    .765 F2    +  .644 E1
COURSES =V2  =    .840*F2    +  .543 E2
PROBLEMS=V3  =    .878*F2    +  .478 E3
 MAT    =V4  =    .644 F3    +  .765 E4
 ALG    =V5  =    .953*F3    +  .304 E5
 ATT1   =V6  =    .814*F1    +  .581 E6
 ATT2   =V7  =    .902*F1    +  .432 E7
  F2    =F2  =    .662*F1    +  .749 D2
  F3    =F3  =    .188*F2    +  .464*F1    +  .796 D3


GOODNESS OF FIT SUMMARY

INDEPENDENCE MODEL CHI-SQUARE =       865.166 ON    42 DEGREES OF FREEDOM

INDEPENDENCE AIC =   781.16583   INDEPENDENCE CAIC =   595.68962
       MODEL AIC =     3.66170          MODEL CAIC =  -106.74081

CHI-SQUARE =       53.662 BASED ON    25 DEGREES OF FREEDOM
PROBABILITY VALUE FOR THE CHI-SQUARE STATISTIC IS LESS THAN 0.001

BENTLER-BONETT NORMED    FIT INDEX=       0.938
BENTLER-BONETT NONNORMED FIT INDEX=       0.942
COMPARATIVE FIT INDEX             =       0.965
```

```
CONSTRAINTS TO BE RELEASED ARE:


        CONSTRAINTS FROM GROUP  2

        CONSTR:   1   (1,F2,F1)-(2,F2,F1)=0;
        CONSTR:   2   (1,F3,F1)-(2,F3,F1)=0;
        CONSTR:   3   (1,F3,F2)-(2,F3,F2)=0;


         UNIVARIATE TEST STATISTICS:

 NO    CONSTRAINT    CHI-SQUARE   PROBABILITY
 --    -----------   ----------   -----------

  1   CONSTR:   1        0.000        0.999
  2   CONSTR:   2        2.736        0.098
  3   CONSTR:   3        1.141        0.285
```

The fit indices indicate a good fit but the authors felt it was not. The LaGrange multipliers indicate no differences between the two structures, although the path F1 to F3 is close. The authors test the following model with the added "path" from F3 to V1 (Achievement to Daily).

```
FILE NAME = MATHGB2.EQS

/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
     Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
     Educational Psychology, 85, 41-48.
/spe
    case=108; var=7; me=ml;  mat=cor;
    groups=2;
/STA
 24.5 23.3 22.2 4.7 14.0 10.0 9.4
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/lmtest
/tec
  itr=150
/EQUATION
```

```
   V1  =   1.000 F2  +   1.000 E1   ;
   V2  =   1.034*F2  +   1.000 E2   ;
   V3  =   1.063*F2  +   1.000 E3   ;
   V4  =   1.000 F3  +   1.000 E4   ;
   V5  =   4.349*F3  +   1.000 E5   ;
   V6  =   8.384*F1  +   1.000 E6   ;
   V7  =   9.448*F1  +   1.000 E7   ;
   F2  =  10.495*F1  +   1.000 D2   ;
   F3  =    .043*F2  +   1.692*F1  + *v1 +   1.000 D3   ;
/VARIANCES
      F1=    1.000  ;
      E1=  263.601* ;
      E2=  190.112* ;
      E3=  119.807* ;
      E4=   14.039* ;
      E5=   16.320* ;
      E6=   32.454* ;
      E7=    2.569* ;
      D2=  224.101* ;
      D3=    5.197* ;
/mat
1.00
 .59 1.00
 .69  .68 1.00
 .24  .38  .29 1.00
 .23  .54  .42  .58 1.00
 .38  .43  .44  .20  .48 1.00
 .35  .52  .47  .32  .61  .81 1.00
/end
/title
 Mathematics Achievement of girls and boys form Randhawa, B. S.,
    Beamer, J. E., & Lundberg, I. (1993) Role of math..... Journal of
    Educational Psychology, 85, 41-48.
/spe
   case=117; var=7; me=ml;  mat=cor;
   groups=2;
/lmtest
/labels
  v1=daily;    v2=courses;    v3=problems;    v4=mat;
  v5=alg;      v6=att1;       v7=att2;
/STA
 20.7 20.8 20.4 5.9 15.4 8.9 9.1
/tec
  itr=150
```

```
/EQUATION
   V1  =   1.000 F2  +   1.000 E1   ;
   V2  =   1.034*F2  +   1.000 E2   ;
   V3  =   1.063*F2  +   1.000 E3   ;
   V4  =   1.000 F3  +   1.000 E4   ;
   V5  =   4.349*F3  +   1.000 E5   ;
   V6  =   8.384*F1  +   1.000 E6   ;
   V7  =   9.448*F1  +   1.000 E7   ;
   F2  =  10.495*F1  +   1.000 D2   ;
   F3  =    .043*F2  +   1.692*F1  + *v1 +  1.000 D3   ;
/VARIANCES
      F1=    1.000  ;
      E1=  263.601* ;
      E2=  190.112* ;
      E3=  119.807* ;
      E4=   14.039* ;
      E5=   16.320* ;
      E6=   32.454* ;
      E7=    2.569* ;
      D2=  224.101* ;
      D3=    5.197* ;
/mat
1.00
 .65 1.00
 .70  .72 1.00
 .18  .37  .44 1.00
 .22  .47  .48  .65 1.00
 .37  .54  .46  .35  .49 1.00
 .38  .55  .53  .43  .55  .74 1.00
/con
(1,f2,f1)=(2,f2,f1);
(1,f3,f1)=(2,f3,f1);
(1,f3,f2)=(2,f3,f2);
(1,f3,v1)=(2,f3,v1);
```

```
  MEASUREMENT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS



 DAILY    =V1  =     1.000 F2     +  1.000 E1
```

```
COURSES =V2  =    1.048*F2    +  1.000 E2
                   .118
                  8.905

PROBLEMS=V3  =    1.022*F2    +  1.000 E3
                   .112
                  9.111

  MAT   =V4  =    1.000 F3    +  1.000 E4



  ALG   =V5  =    4.352*F3    +  1.000 E5
                   .601
                  7.238

  ATT1  =V6  =    8.489*F1    +  1.000 E6
                   .814
                 10.425

  ATT2  =V7  =    9.256*F1    +  1.000 E7
                   .732
                 12.644
```

CONSTRUCT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS

```
  F2   =F2  =   10.748*F1    +  1.000 D2
               1.326
               8.104

  F3   =F3  =    -.065*V1    +   .131*F2    +  1.331*F1    +  1.000 D3
                .017          .029          .314
              -3.920         4.573         4.241
```

STANDARDIZED SOLUTION:

```
DAILY    =V1  =     .758 F2    +   .652 E1
COURSES  =V2  =     .822*F2    +   .570 E2
PROBLEMS =V3  =     .841*F2    +   .541 E3
  MAT    =V4  =     .649 F3    +   .761 E4
  ALG    =V5  =     .977*F3    +   .213 E5
  ATT1   =V6  =     .839*F1    +   .543 E6
  ATT2   =V7  =     .970*F1    +   .243 E7
  F2     =F2  =     .586*F1    +   .810 D2
  F3     =F3  =    -.485*V1    +   .743*F2    +   .411*F1    +   .641 D3
```

MEASUREMENT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS

```
DAILY    =V1  =    1.000 F2    +  1.000 E1


COURSES  =V2  =    1.068*F2    +  1.000 E2
                   .108
                  9.846

PROBLEMS =V3  =    1.104*F2    +  1.000 E3
                   .106
                 10.386
```

```
MAT    =V4  =    1.000 F3    +  1.000 E4



ALG    =V5  =    3.943*F3    +  1.000 E5
                  .608
                 6.483

ATT1  =V6  =    7.202*F1    +  1.000 E6
                  .722
                 9.976

ATT2  =V7  =    8.097*F1    +  1.000 E7
                  .723
                11.200
```

CONSTRUCT EQUATIONS WITH STANDARD ERRORS AND TEST STATISTICS

```
F2   =F2  =   10.748*F1    +  1.000 D2
              1.326
              8.104

F3   =F3  =    -.065*V1    +   .131*F2    +  1.331*F1    +  1.000 D3
               .017           .029           .314
             -3.920          4.573          4.241
```

STANDARDIZED SOLUTION:

```
DAILY    =V1  =     .775 F2     +   .633 E1
COURSES  =V2  =     .836*F2     +   .549 E2
PROBLEMS =V3  =     .881*F2     +   .474 E3
  MAT    =V4  =     .631 F3     +   .775 E4
  ALG    =V5  =     .942*F3     +   .335 E5
  ATT1   =V6  =     .817*F1     +   .577 E6
  ATT2   =V7  =     .900*F1     +   .436 E7
   F2    =F2  =     .664*F1     +   .748 D2
   F3    =F3  =    -.387*V1     +   .605*F2    +   .380*F1    +   .741 D3
```

```
        CONSTRAINTS FROM GROUP  2

        CONSTR:   1   (1,F2,F1)-(2,F2,F1)=0;
        CONSTR:   2   (1,F3,F1)-(2,F3,F1)=0;
        CONSTR:   3   (1,F3,F2)-(2,F3,F2)=0;
        CONSTR:   4   (1,F3,V1)-(2,F3,V1)=0;


         UNIVARIATE TEST STATISTICS:

  NO     CONSTRAINT     CHI-SQUARE   PROBABILITY
  --    -----------    ----------    -----------

   1    CONSTR:   1         0.001         0.977
   2    CONSTR:   2         2.122         0.145
   3    CONSTR:   3         1.213         0.271
```

```
 4    CONSTR:   4        0.029       0.864



     CUMULATIVE MULTIVARIATE STATISTICS              UNIVARIATE INCREMENT
     ----------------------------------              --------------------

 STEP  PARAMETER   CHI-SQUARE  D.F.  PROBABILITY       CHI-SQUARE  PROBABILITY
 ---- -----------  ----------  ----  -----------       ----------  -----------

   1  CONSTR:   2      2.122      1      0.145            2.122       0.145
   2  CONSTR:   4      2.683      2      0.261            0.561       0.454
   3  CONSTR:   3      6.226      3      0.101            3.543       0.060
   4  CONSTR:   1      6.229      4      0.183            0.003       0.960
```

This model has an excellent fit. There are no differences between the two groups, although, the .09 comes close to being significant. On to the discussion section of the article. The analyses performed here concurs with the first sentence of the discussion section that M-Efficacy (self-efficacy) is a mediating variable. The last part of that paragraph is good reporting for data as presented by the authors but not for the new analyses. They were cautious "...the hypothesized model for boys and girls to be equal might hot have been sustained" but it seems to me that in our analyses it was sustained. The next paragraph "In the two-group solution...." the reporting is good for their data. They state that means for the groups were different but they are not reported in the results section. Good supporting evidence from other studies.

The last sentence in the first paragraph on page 47 is curious "A test of the model..." Why didn't they test such a constrained model? In fact, however, in the above test there were no differences. It seems to me that there conclusions are correct "Girls as a group, because of their significantly lower perceptions of mathematics self-efficacy, are thus at greater risk than boys." Such a conclusion cannot be drawn from the structural models but from the differences in the means. The structural models as tested here are the same. So that the process for the two groups are the same (if a given member of either gender has "math experiences" and beliefs the well be more likely to do better in math. It turns out that boys are more likely than girls to such experiences. However, the model is the same for the two groups.