

## Structural Equation Modeling Seminar

**Location:** CIQSS, 3535 Queen-Mary, Suite 420, Montreal

**Dates:** April 22–26, 2013

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### Course Objectives and Content

This intensive, graduate-level, five-day seminar deals with the principles, assumptions, strengths, limitations, and applications of the family of techniques known as structural equation modeling (SEM). Basic SEM techniques, including path analysis, confirmatory factor analysis (CFA), and full “LISREL” (structural regression) models, will be covered. Some familiarity with basic statistical techniques, such as multiple regression and exploratory factor analysis, is assumed, but higher levels of quantitative knowledge are not required.

The presentation of topics will be conceptually rather than mathematically oriented, and many examples of the application of SEM to different kinds of actual research problems are considered. There will be a strong emphasis on avoiding common kinds of mistakes in the analysis of structural equation models. Computer tools for SEM will be described, and there will be opportunities for participants to gain hands-on practice with actual SEM analyses on site.

### Trainer

This training session will be under the responsibility of Dr. Rex B. Kline, Professor, Department of Psychology, Concordia University.<sup>1</sup>

### General Course Information

The sessions are in English. Computer practice with the student version of LISREL 9.1 will be held during the afternoon sessions of Tuesday and Wednesday. The LISREL student version can be freely downloaded from

<http://www.ssicentral.com/lisrel/student.html>

### Schedule

The seminar is scheduled from **9:00am to 5:00pm**.

### Seminar Web Site

The web page for this seminar will be available about one month before the workshop:

<http://psychology.concordia.ca/fac/kline/sem/qicss.html>

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<sup>1</sup>514-848-2424, ext.7556; [rex.kline@concordia.ca](mailto:rex.kline@concordia.ca); <http://tinyurl.com/rexkline>

## Eligibility

The course is open to graduate students and postdoctoral fellows as well as to professors and applied researchers. A maximum of 15 participants will be selected on the basis of the relevance of the course to their curriculum, research, or teaching.

## Main Source (optional)

Kline, R. B. (2010). *Principles and practice of structural equation modeling* (3rd ed.). New York: Guilford Press. (See book resource site at <http://www.guilford.com/kline>)

## Other Seminar Readings (see seminar web page)

MacCallum, R. C., & Austin, J. T. (2000). Applications of structural equation modeling in psychological research. *Annual Review of Psychology*, 51, 201–226. doi:10.1146/annurev.psych.51.1.201

Sava, F. A. (2002). Causes and effects of teacher conflict-inducing attitudes towards pupils: A path analysis model. *Teaching and Teacher Education*, 18, 1007–1021. doi:10.1016/S0742-051X(02)00056-2

Shah, R., & Goldstein, S. M. (2006). Use of structural equation modeling in operations management research: Looking back and forward. *Journal of Operations Management*, 24, 148–169. Retrieved from <http://www.journals.elsevier.com/journal-of-operations-management/>

## Topics Schedule

Day 1: Background concepts: Data preparation, overview of computer tools, types of SEM models

Day 2: Path analysis: Effects, estimation, testing, Amos example, computer practice

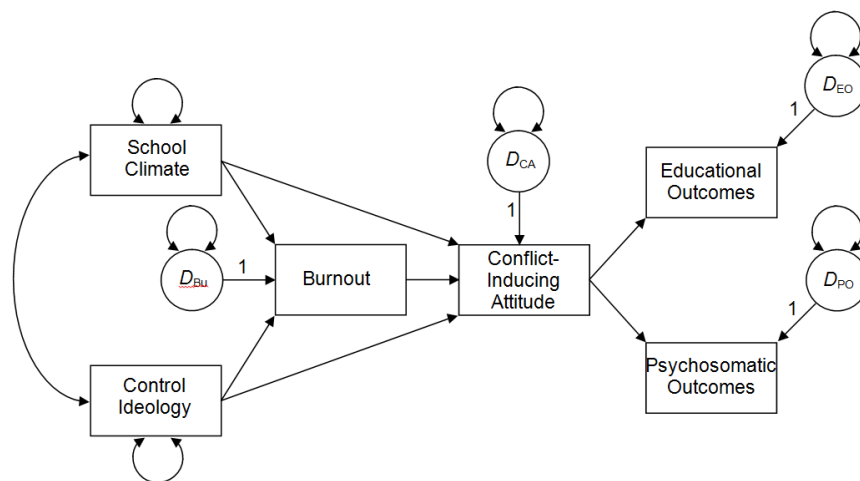
Day 3: Confirmatory factor analysis: Models, nonnormality, EQS example, computer practice

Day 4: Structural-regression model: Variations, LISREL example

Day 5: Finish scheduled topics, open question period

## Computer Practice

The task is to reproduce the path analysis of teacher and student variables by Sava (2002), the diagram of which is presented next in Reticular Action Modeling (RAM) format:



For Day 1, adapt the LISREL SIMPLIS syntax presented next for a four-variable path model by Nezu and Ronan (1989) (presented below) for the six-variable path model by Sava (2002), as follows:

1. In the LISREL editor, select New | Syntax Only, and then save the empty syntax file as "sava.spl."

- In SIMPLIS syntax, specify  $N = 109$ , and the input data will be the variance-covariance matrix in lower diagonal form reported in Table 3 of Sava (2002), shown below:

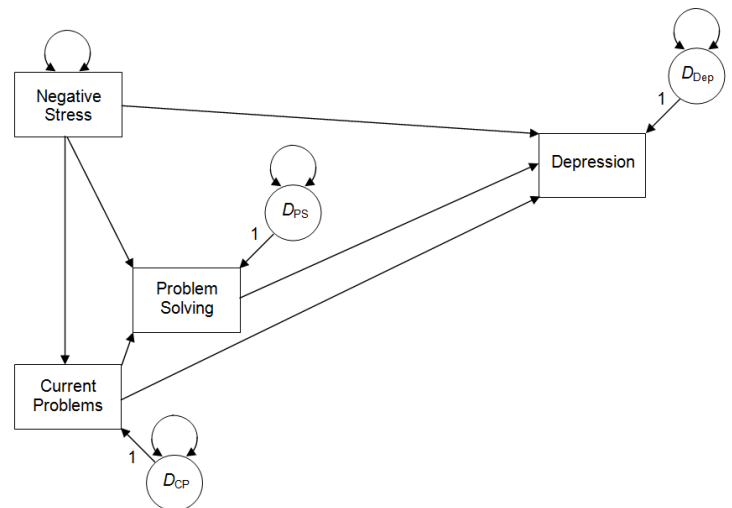
Table 3  
Input covariance and correlation matrices for path analysis

	1	2	3	4	5	6
1. PCI	69.009					
Pupil control ideology	—					
2. MBI	28.867	95.446				
Burnout	(0.36***)	—				
3. CQ	-22.427	-49.074	110.695			
School climate	(-0.26**)	(-0.48***)	—			
4. PC-1	-3.361	0.202	1.961	1.000		
Conflict-inducing attitude	(-0.40***)	(0.02)	(0.19*)	—		
5. EDUC	-4.988	3.408	2.810	2.432	13.822	
Educational outcomes	(-0.16)	(0.09)	(0.07)	(0.65***)	—	
6. PSI	-15.269	-0.687	8.709	3.836	9.728	27.788
Psychosomatic outcomes	(-0.35***)	(-0.01)	(0.16)	(0.73***)	(0.50***)	—

The correlations are presented within parenthesis.  
\* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$  (two-tailed).

- Note that LISREL syntax is case sensitive, and variable names are limited to eight characters. The hyphen character (“-”) is read in LISREL as a minus sign (i.e., an arithmetic operator), not as an alphanumeric character, so do not use it in a variable name. For example, use “PC\_1” as a name instead of “PC-1,” which will cause an error. Run the syntax by clicking on the Run LISREL icon.
- If the analysis is correctly specified, the model chi-square shown on screen will be  $\chi^2(7) = 3.712$ . This statistic is what is labeled in LISREL text output as the “Normal Theory Weighted Least Squares Chi-Square,” but ordinarily it is the “Minimum Fit Function Chi-Square” that is reported, which for the Sava (2002) analysis is  $\chi^2(7) = 3.895$ . The latter is reported in the LISREL output file but not in the path diagram. Note that Sava (2002) reports error standard deviations, not error variances, which are listed in LISREL output.
- The SIMPLIS syntax to be adapted along with its corresponding path model are presented next:

```
Nezu & Ronan (1989)
Observed Variables
neg_str cur_prob prob_sol depress
Correlation Matrix
1.000
.402 1.000
.176 .335 1.000
.404 .553 .452 1.000
Standard Deviations
8.77 15.79 21.87 6.14
Sample Size is 205
Relationships
cur_prob = neg_str
prob_sol = neg_str cur_prob
depress = neg_str cur_prob prob_sol
LISREL Output: ND = 3 SC RS MI
Path Diagram
End of Problem
```



For Day 2, repeat the same analysis but now using the LISREL path diagram editor, as follows:

- Save the variance-covariance matrix for the Sava (2002) analysis from Day 1 in an external text (ASCII) file (e.g., create it in Windows Notepad), and name it “sava.dat.”
- In the LISREL editor, select New | Path Diagram, and save the empty diagram file as “sava.pth.”

3. Next, use the Setup menu to specify the data file, variable names, and sample size before drawing the model on the screen. Check the boxes for the endogenous variables (Observed Y) before dragging and dropping the observed variables from the list to the drawing palette. Select View | Toolbars | Drawing Bar to display the shape tools, if not already visible.
4. When finished drawing the model, generate the LISREL SIMPLIS syntax by selecting Build SIMPLIS Syntax under the Setup menu. Then run the syntax by clicking on the Run LISREL icon.
5. The unstandardized path coefficients and error variances are initially shown in the path diagram. To see the standardized estimates, select Standardized Solution option from the Estimates pull-down menu of the diagram editor.

## Other Software Resources

Listed below are freely-available versions of some other SEM computer tools that can be downloaded over the Internet:

<u>Program</u>	<u>Web address</u>	<u>Limits</u>
Amos 5 student version	<a href="http://amosdevelopment.com/download/">http://amosdevelopment.com/download/</a>	8 variables
LISREL 9.1 full version	<a href="http://www.ssicentral.com/lisrel/downloads.html">http://www.ssicentral.com/lisrel/downloads.html</a>	15-day trial
Mx Graph full version	<a href="http://www.vcu.edu/mx/index.html">http://www.vcu.edu/mx/index.html</a>	—
Mplus demo version	<a href="http://www.statmodel.com/demo.shtml">http://www.statmodel.com/demo.shtml</a>	8 variables
STATISTICA full version	<a href="http://www.statsoft.com/support/free-statistica-10-trial/">http://www.statsoft.com/support/free-statistica-10-trial/</a>	30-day trial