

# SYA 6936: Structural Equation Models (SEM) and Latent Variables Spring 2014

11:00am-2pm; Thursday; 236 Pepper

Instructor: Dr. Miles Taylor, 232 Pepper Center Bldg, 644-5418, mtaylor3@fsu.edu

Office Hours: Wednesday, 9:30am-12pm; *call first to verify I'm not in another meeting*

Course TA: Janet Weeks, jaw10@my.fsu.edu

Web page: Blackboard site on campus.fsu.edu

## Course Description

Structural Equation Modeling (SEM) is a general class of multivariate modeling techniques that allows the estimation of relationships between latent (unobserved) variables free of measurement error extant in observed variables. SEM is general in the sense that virtually all modeling techniques used in sociology today are special cases of the general model. For example, OLS regression is a special case of SEM in which (1) there is one to one correspondence between observed and latent variables (e.g., there is no measurement error) and (2) there is a single outcome (i.e., endogenous or dependent) variable. In part because of their generality and flexibility in software and programming, the popularity and use of SEMs have exploded over the last two decades. Thus, it is difficult to find an issue of any major sociology journal that does not contain at least one article using SEM methods. The purpose of this course is to provide a thorough introduction to these methods. The course is very applied, emphasizing how to use SEM software to estimate models, evaluate them, revise them, and report the results from them. At the same time, the course will provide a rigorous treatment of the theory underlying SEMs, including discussions of causality and inference, model assumptions and consequences of their violation, and limitations. You will be assessed with ten exercises, one quiz, and a final empirical paper. Completion of SYA 5406 and 5407 are required for admission to the course; other graduate-level multiple regression courses may fulfill this prerequisite with instructor's approval. Familiarity with matrix algebra is also required. We will review matrix algebra, but the course will use matrix algebra extensively, so some level of comfort working with matrices is necessary. \*\*\*PLEASE NOTE: I RESERVE THE RIGHT TO ALTER THE SYLLABUS, WE WILL NEED TO BE FLEXIBLE AS THESE MODELS ARE ADVANCED AND WE MAY NOT BE ABLE TO COVER EVERYTHING\*\*\*

## Course Learning Objectives

1. Read and understand published research using SEM's
2. In a given situation, use appropriate criteria to determine if a SEM model is appropriate, and if so which should be used.
3. Become familiar with the Mplus software, its language, and the many observed and latent models types it can estimate.
4. Use Mplus input (syntax) files to generate results for each type of SEM covered.
5. Interpret the output from Mplus, both in terms of individual coefficients (component fit) and in terms of measures of a model's overall goodness of fit.
6. Translate Mplus output into more useful formats, e.g., tables, graphs, figures.
7. Write an empirical research paper using SEM methods.

## Required Texts and Materials

Bollen, Kenneth A. (1989). Structural Equations with Latent Variables. New York: John Wiley & Sons.

Geiser, Christian. (2013). Data Analysis with Mplus. New York: Guilford Press.

Additional readings: Articles, chapters, and handouts to be downloaded from Blackboard.

Scientific calculator will be needed for matrix algebra homework and quiz.

## Course Requirements

1. Ten exercises will be required throughout the semester. With the exception of one matrix algebra assignment, they include computer-based analysis, your interpretation of the results, Mplus syntax and Mplus output. Each assignment is worth 5 points, and together they account for 50 percent of your course grade. The exercises are due by the start of the next class period (or one week) after they are given. It is your responsibility to confirm that you have successfully submitted them. Late exercises will be penalized one letter grade (i.e. from A to B) per day they are late (see grading rubric on next page), unless you have written beforehand with a valid excuse for the delay and a specific plan for when it will be submitted. The analysis for exercises will be primarily performed during the second half of class (lab) on the day they are given. It is **HIGHLY RECOMMENDED** that you use this lab time to perform them, since you will have both the instructor and the TA there to help troubleshoot the models and the syntax. You **MAY** help each other with coding issues but please do not work together on the exercises or their write-ups.
2. There will be one quiz covering matrix algebra and SEM notation/equations, accounting for 10 percent of your grade.
3. The course includes a final paper that is worth 40 percent of your grade. This will be an empirical paper using the SEM techniques covered in the class on a topic of your own interest using your own data. This paper is expected to be of publishable quality and in journal format. As with the exercises, for every day this is late I will reduce by one letter grade (i.e. from A to B).

### Grading Summary

(10) Assignments @ 5	50 points	A	90 – 100% of total points
(1) Quiz @10	10 points	B	80 – 89%
(1) Final Paper @ 40	40 points	C	70 – 79%
<u>TOTAL</u>	<u>100 points</u>	D	60 – 69%
		F	below

I also assign pluses and minuses according to standard FSU guidelines. For grades A through D, the bottom 3 points in each grade range will receive a “-” (e.g., 80 to 82 = B-). For a grade of B, C, or D, the top 3 points in each grade range will receive a “+” (e.g., 77 to 79 = C+).

### Assignments

5 pts – no errors or, at most, very minor mistakes in math, programming or in wording, well written; great job

- 4 pts – no major errors but did not fully address one or more of the questions was asking; or a single error in terms of interpretation or model/test execution; a good job overall
- 3 pts – two major errors in execution or interpretation, or incomplete answers; shows a good level of effort but inadequate attention to or knowledge of details
- 1-2 pts – more than two major errors in execution or interpretation; suggests inadequate effort or serious confusion about the models featured in the assignment
- 0 pts – if you copy another student’s syntax or report, you will receive no credit  
(1 pt deduction for late assignments per day they are late without prior authorization.)

### Final Paper

This is worth 40 percent of your final grade, therefore you should take it seriously and begin working on it within the first few weeks of class. I expect this to look like a publishable empirical piece using SEM analysis and Mplus, and the hope is that it may lead to a publication for students. Much like your assignments in 5407, I do not expect as much “front end” material (theory/literature review) but I DO expect a more thorough discussion of the methods and results sections compared to what is usually found in journal articles. I will give you an example of an acceptable class paper. Please remember to start early on preparing your data. I will consider “shared” papers that students may also be writing for a substantive class and papers for projects students plan to coauthor. However, I expect to meet with students and agree to guidelines for these on a per case basis and I expect the work you turn in to me to be (1) at least 3/4 original to this class and (2) entirely your own work on analysis/programming and writing.

### **Computer Assignments**

#### Data Sets

This course entails completion of 9 computer exercises (one exercise is simply math and notation homework). They are intended to give you experience in the application of different types of SEM/Latent Variable Models. For all of the computer based assignments, I have provided data sets for you to use and explicitly ask you to model certain variables in the data. Therefore you will not need to use your own data until your final paper.

You’ll submit three separate documents for each assignment and your name should be in the file name of each: (1) a Word file with a review of what you did in the assignment and your answers to exercise questions (in paragraph form), (2) your Mplus input file(s) in text or pdf format (so we can grade from anywhere) and (3) your Mplus output file(s) in text or pdf format.

Throughout the class, I encourage you to work with your classmates when grappling with the text or when debugging syntax problems. However, you may not “check” your answers with your classmates on the exercises and the work you complete must be your own. You must work independently on your final paper unless you have a coauthor situation that is approved by me. Ideally the data set for your final project will be one with which you are currently working. I also have a large number of data sets handy for your use (ACL, EPESE, NSFH, GSS, etc.).

Where to Access/Purchase Mplus: We will be working with the Demo version of Mplus in our classroom, which will run all the SEM models but has some limitations on number of variables. The sociology graduate student computer lab has multiple (full) copies of Mplus. Unfortunately,

the computer lab is not large enough to accommodate all the students in this class. You may wish to buy a copy of Mplus and, if so, I suggest you do so as a student. This is because the pricing for the same software is drastically reduced for students. You may find information on student pricing and how to purchase Mplus at: <http://www.statmodel.com/pricing.shtml#student>. Please note that some of the models we will cover in class require “add on” versions of Mplus and not merely the base program. Check with me if you have questions on which version to buy.

Problems with Mplus: When you run into errors while running Mplus, try these sources of help.

1. Consult the in-program Help menu and use the search function to examine the syntax rules for the type of command you are trying to run.
2. Ask a classmate for assistance with your error.
3. Ask your TA or me. If you want to ask us about an error, you must produce both your syntax file and the output file showing the error (if asking for help via email, send both as attachments). Without these files we will not be able to provide you with assistance.
4. Search the online version of the Mplus User’s Guide at: <http://www.statmodel.com/ugexcerpts.shtml> and/or search the online Discussion Board.
5. When all else fails, try googling “mplus ....”.

### **Blackboard Technical Matters**

It is your responsibility to confirm that you have successfully submitted an online survey or the three files that make up an assignment. For each of these, after submitting you should look in the grades section of Blackboard to verify your survey or assignment was submitted. It should show an exclamation mark (!) indicating “Needs to be graded” and not the symbol of a lock (🔒) that indicates “In progress” or a dash (-) that indicates Blackboard has no record of you trying to submit anything. If you get the dash symbol, it means you can try again. If you get the lock symbol, you likely will not be able to open the assignment or survey again. In this situation, write the TA or me as soon as possible, then check your email for a reply that reports we’ve cleared the gradebook entry and you can try again. Obviously, you should always keep copies of the files you submit for an assignment. Failing to confirm your submission is not a valid excuse for it being late.

### **Other Information**

Honor code: This course will uphold the University Honor Code that is based on the premise that each student makes a commitment to avoid any violation of academic integrity (cheating) and refuses to tolerate violations (report cheating). The FSU Main Campus Student Handbook lists the Academic Honor Policy ([http://registrar.fsu.edu/student\\_handbook/handbook\\_tal.pdf](http://registrar.fsu.edu/student_handbook/handbook_tal.pdf)).

Americans with Disabilities Act: Students with disabilities needing academic accommodation should: (1) register with and provide documentation to the Student Disability Resource Center;

and (2) bring a letter to the instructor indicating the need for accommodation and what type. For more information about services for FSU students with disabilities, contact:

Student Disability Resource Center	(850) 644-9506 (voice)
08 Kellum Hall	(850) 644-8504 (TDD)
Florida State University	SDRC@admin.fsu.edu
Tallahassee, FL 32306-4400	

Class Attendance: University policy requires that I take attendance during *every* class session. Students who have ***more than 2 unexcused absences during the semester will be downgraded***; students who have ***more than 3 unexcused absences during the semester will receive a failing grade for the course***.

Only the following absences are eligible to be excused:

- 1) Religious holidays as specified in FSU policy. *Students who miss class due to observance of religious holidays must speak with me in advance*;
- 2) Representing FSU at official functions, including intercollegiate club or varsity sports events;
- 3) Verified emergencies and/or medical illness. Medical illnesses are serious in nature and require continued treatment by medical professionals and/or surgical or other treatments. *Colds and fatigue do not qualify as medical illnesses. If you have a chronic illness that could affect your attendance, it is imperative that you alert me to this at the beginning of class.*

***Documentation is required for an absence to be excused.*** Please provide a copy of the documentation to me and keep a copy for your own records. While I will not penalize you for excused absences, you remain responsible for all content missed, including assignments, knowledge, or skills that were covered in the missed class(es).

### **Outline of Course Topics and Due Dates**

Required reading: [B] = Bollen book; [G] = Geiser book  
Optional reading: listed

Week 1. January 9, 2014

Lecture Topics: Overview of structural equation modeling (SEM) and its uses  
Overview of Latent Variables

Lab Topics: Introduction to Mplus software and language  
Getting data read into Mplus

Required Reading: [B] Chap. 1 plus pages 10-11, [G] Chap. 1-2

Optional Reading: See blackboard for additional intro to SEM texts; Mplus User's Guide Chapter 1-2 (available online: <http://www.statmodel.com/ugexcerpts.shtml> ).

Exercise 1: Transferring Data to Mplus, due 1/23.

Week II. January 16, 2014

Lecture Topics: Review of Matrix Algebra and multiple regression in matrix form  
SEM notation and terminology

Lab Topics: Matrix Algebra and SEM, cont.  
Reading student data into Mplus

Required Reading: [B] Chapter 2 & 3, App. A&B, [G] Pg.s 24-27

Optional Reading: See blackboard for additional intro to Matrix Algebra

Exercise 2: Matrix Algebra and SEM notation, due 1/23.

- Week III. January 23, 2014
- Lecture Topics: Causality in the SEM framework  
Identification and Estimation  
Overall Fit Statistics and Indices
- Lab Topics: Simple Linear Regression in SEM/Mplus
- Required Reading: [B] Chapter 3-4, pg.s 256-281 [G] pg.s 28-51
- Optional Reading: TBA
- Exercise 3: Simple Linear Regression in the SEM Framework, due 1/30.
- Week IV. January 30, 2014
- Lecture Topics: Measurement Error and Measurement Models  
Confirmatory Factor Analysis (CFA)
- Lab Topics: Confirmatory Factor Analysis (CFA)
- Required Reading: [B] Chapter 5-7, [G] Pg.s 51-61
- Optional Reading: TBA
- Exercise 4: Confirmatory Factor Analysis (CFA), due 2/13.
- Week V. February 13, 2014
- Lecture Topics: Multiple Indicator-Multiple Cause (MIMIC) Models  
Full SEM's (with exogenous and endogenous latent variables)
- Lab Topics: Multiple Indicator-Multiple Cause (MIMIC) Models
- Required Reading: [B] Chapter 8, [G] Pg.s 62-80 \*\*Reading is for 2 weeks\*\*
- Optional Reading: TBA
- Exercise 5: Multiple Indicator-Multiple Cause (MIMIC), due 2/20.
- Week VI. February 20, 2014
- Lecture Topics: Path Analysis  
Direct and Indirect Effects  
Mediators and Moderators
- Lab Topics: Manifest and Latent Path Analysis
- Required Reading: [B] Chapter 8, [G] Pg.s 62-80 \*\*Reading is for 2 weeks\*\*
- Optional Reading: TBA
- Exercise 6: Manifest and Latent Path Analysis, due 2/27.
- Week VII. February 27, 2014
- Lecture Topics: More Complicated Models: Nonrecursive Models, imposing constraints, etc.  
Multiple Group Analysis
- Lab Topics: Multiple Group Analysis
- Required Reading: [B] Chapter 9 \*\*Reading is for 2 weeks\*\*, Handouts
- Optional Reading: TBA
- Exercise 7: Multiple Group Analysis Models, due 3/6.
- Week VIII. March 6, 2014
- Lecture Topics: Other Topics: Alternate Estimators

Missing Data Strategies  
Lab Topics: TBA  
Required Reading: [B] Chapter 9 \*\*Reading is for 2 weeks\*\*, Handouts  
Optional Reading: TBA  
Exercise: None

Week IX. March 20, 2014

Lecture Topics: Extensions: Latent Growth Curve Models  
Introduction and Estimation  
Unconditional Model  
Lab Topics: Unconditional Model  
Required Reading: [G] Chapter 4, Handouts \*\*Reading is for 2 weeks\*\*  
Optional Reading: TBA  
Exercise 8: Unconditional Latent Growth Curve Model, due 3/27

Week X. March 27, 2014

Lecture Topics: Extensions: Latent Growth Curve Models  
Alternative Approaches to Time  
Conditional Model  
Lab Topics: Conditional Model  
Required Reading: [G] Chapter 4, Handouts\*\*Reading is for 2 weeks\*\*  
Optional Reading: TBA  
Exercise 9: Conditional LGC Model, due 4/3

Week XI. April 3, 2014

Lecture Topics: Extensions: Latent Class Analysis (LCA)  
Known vs. Unknown Groups  
Cross Sectional LCA  
Lab Topics: Cross Sectional LCA  
Required Reading: [G] Chapter 6, Collins and Lanza Ch.s 1,2,6  
Optional Reading: TBA  
Exercise 10: Cross Sectional LCA, due 4/10

Week XII. April 10, 2014

Lecture Topics: Extensions: Latent Class Analysis (LCA)  
Longitudinal LCA's and GMM's  
Lab Topics: TBA  
Required Reading: [G] Chapter 6, Collins and Lanza, Ch. 7, Muthen's Chapter 19 in  
Kaplan book (see BB)  
Optional Reading: TBA  
Exercise: None/Optional

Week XIII. April 17, 2014 \*\*\*\*Final Papers Due\*\*\*\*\*

Lecture & Lab Topics: Paper Presentations  
Exercise: None/Optional

Week XIV. April 24, 2014

Lecture & Lab Topics: Paper Presentations

Exercise: None/Optional

**Additional Required Reading (Handouts)**

Bollen, Kenneth A. and Patrick J. Curran. (2005). *Latent Curve Models: A Structural Equation Perspective*. Wiley Series in Probability and Statistics. (excerpts)

Collins, Linda M. and Stephanie T. Lanza (2010). *Latent Class and Latent Transition Analysis: With applications in the Social, Behavioral, and Health Sciences*. Wiley. (excerpts)