EDUCATIONAL RESEARCH METHODOLOGY
STRUCTURAL EQUATION MODELING (*ERM-731*)

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<u>Overview of the Course</u>

This course is intended for doctoral-level students (and faculty) interested in learning about a collection of statistical techniques commonly referred to as "structural equation models" (SEM). The primary objectives of this course are to provide students with the opportunity to: (1) understand the theoretical factor analytic and measurement principles underlying SEM; (2) recognize research situations where SEM may be useful; (3) understand some of the technical issues and limitations involving the use of SEM; (4) use available SEM analysis software on real data sets and interpret the analysis results; and (5) critique the use of SEM in published research.

The course will include some lecture, but will be principally conducted in a seminar format to encourage open discussions and dialog. Lectures will be limited to describing various technical aspects of SEM and demonstrations. Class discussions and student presentations will also be incorporated to encourage active participation on everyone's part in learning about SEM.

<u>Course Materials</u>

The *required* course textbook is

> Raykov, T. & Marocoulides, G. A. (2000). A First Course in Structural Equation Modeling. Mahwah, NJ: Lawrence Erlbaum Associates. [Available in UNCG Bookstore.]

Other recommended [optional] textbooks are listed below:

> Bollen, K. A. (1989). *Structural Equations with Latent Variables*. New York: John Wiley & Sons.
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> Bollen, K. A. & Long, J. S. (Eds). (1993). *Testing Structural Equation Models*. Thousand Oaks: Sage Publications.
>
> Hoyle, R. H. (Ed.). (1995). *Structural Equation Modeling: Concepts, Issues, and Applications*. Thousand Oaks: Sage Publications. [Available in UNCG Bookstore.]

Kaplan, D. (2000). *Structural Equation Modeling: Foundations and Extensions*. Thousand Oaks, CA: Sage Publications

Kelloway, E. K. (1998). *Using LISREL for Structural Equation Modeling: A Researcher's Guide.* Thousand Oaks: Sage Publications.

Kenny, D. A. (1979). *Correlation and Causality.* New York: John Wiley & Sons.

Maruyama, G. M. (1998). *Basics of structural equation modeling*. Thousand Oaks, CA: Sage Publications (available from the UNCG bookstore and from www.amazon.com).

Students are also encouraged to join SEMNET, a discussion list service that includes over 1,500 individuals in over 76 countries. To join, visit the website at

http://www.gsu.edu/~mkteer/semnet.html

Two SEM computer programs are available on the campus network: (1) *AMOS* (versions 3.6 and 4.0) by James Arbuckle, published by Smallwaters Corporation; and *LISREL* 8 by Karl Jöreskog and Dag Sörbom, published by Scientific Software International (most current version is LISREL 8.52). You will need to use these software packages for completing some of the homework and for the midterm examination. Students may also purchase their own versions of either software package or use an approved version of other SEM software.

NOTE: Scientific Software International (SSI) offers a restricted, student version of LISREL 8.52 free of charge. The executable installation package can be downloaded from the SSI website: http://www.ssicentral.com (click on the hyperlink for "Free Downloads").

Supplementary book chapters and journal article reprints will be made available throughout the course of the semester. Students will be expected to read these materials and, in some cases, present selected topics to the class and lead discussions.

Course Requirements, Exams, Projects and Grading

You are expected to attend ALL of the lectures/discussions. Please advise me in advance if you need to miss class. It is your responsibility to acquire any materials, notes, information or handouts from classes that you miss. Also, please come prepared for every class by completing the required reading and any outside work.

There will be one midterm examination, a final examination, and a required final project. The examinations and the final project are described below.

Midterm Examination. The midterm examination will be a "take home" examination consisting of essay-type questions and some problems requiring statistical analyses. The examination will be scored on a scale of 0 to 100 points. Failure to turn in your test on or before the assigned date will result in a score of zero points and a failing grade in this course. Letter grades will be assigned using the following intervals.

A	90 to 100
B	80 to 89
C	79 and below

Final Examination. The final examination will be a "take home" examination consisting of essay-type questions and some problems requiring statistical analyses. The examination will be scored on a scale of 0 to 100 points. Failure to turn in your test on or before the assigned date will result in a score of zero points and a failing grade in this course. Letter grades will be assigned using the following intervals.

A	90 to 100
B	80 to 89
C	79 and below

Final Project. The final project will involve *conducting a re-analysis* of an existing data set, from an approved and published source. This must be an <u>individual</u> project; shared or collaborative projects will not be accepted. (Using your dissertation or thesis data or data related to an outside job is strongly discouraged.)

You will need to have access to the raw data, correlation or covariance matrix from the original study. You will be expected to conduct the data analysis using available SEM software. You should consider proposing and testing alternative models, as appropriate. Finally, you must prepare a 8- to 10-page application paper summarizing the research, your analysis methods, and findings. This paper should be written as if you are submitting it to a journal for publication (e.g. using APA style, word processed with figures and tables, as appropriate). Include any supporting computer printouts from your analysis as an appendix to the paper. With the prior approval of your professor, data from an original research study may be substituted (e.g. using your own dissertation research data). The final project will be graded using letter grades (A=excellent…F=not completed or extremely poor performance). If you fail to complete and hand in the final project *on time*, you will receive a failing grade.

Homework. Homework will be assigned, as appropriate, but is *voluntary* to complete. If you complete the homework, and turn it in on the assigned date, it will be "corrected" and returned to you. You may find the homework useful in preparing for the midterm examination, or merely to receive free feedback about your progress and understanding of the material.

The letter grades for your midterm examination, final examination and final project will be equally considered (weighted) in arriving at your final grade. The following letter-grade patterns will apply.

Grade Pattern (any order)	Final Grade	Grade Pattern (any order)	Final Grade	Grade Pattern (any order)	Final Grade
AAA	A	ABC	B	BCC	C+
AAB	A–	ACC	B–	CCC	C
AAC	B+	BBB	B	Missing ≥ one	W
ABB	B+	BBC	B–		

Course Outline

Because of the diverse technical aspects of SEM and the intended seminar/open discussion format of the course, a good deal of flexibility is necessary in scheduling topics. After a brief overview of SEM, we will start with the basic principles of correlation and covariance, work quickly through regression to and then move on to factor analysis (i.e. using exploratory and confirmatory factor analysis.). From there, we will move into the realm of structural equation modeling. During the semester, we will discover some new language associated with SEM, including an introduction to the matrix notation of LISREL (a well-known software program for conducting SEM analyses).

The primary class session topics to be covered include:

1. An overview of SEM: path diagrams, constructs/latent variables, and observed variables. (Raykov & Marcoulides, Ch. 1)

2. Model elements and the algebra of variance and covariance, including partial correlation. An introduction to path analysis. (Raykov & Marcoulides, Ch. 3)

3. Random and nonrandom measurement error: effects on path models. Includes and an introduction to reliability and measurement errors (conditional and unconditional). (RML handouts: also see Bollen)

4. The process of structural equation modeling: theoretical considerations and hypotheses, model specification, identification, estimation of SEM parameters, evaluating model fit, and model modification. (RML handouts: also, Hoyle, Ch. 1, 2)

5. Preparing and using an SEM blueprint table to document measurement model(s). (RML handouts)

6. Introduction to LISREL. Understanding the matrix notation of LISREL. LISREL was one of the first SEM software packages available to researchers and quickly became the

mainstay of much of the early published research about SEM. This topic will introduce the eight matrices of LISREL and provide a working framework for conducting SEM analyses in subsequent sessions. (Raykov & Marcoulides, Ch. 2; also, Kelloway, Ch. 4)

7. Using LISREL. The measurement model via LISREL: constrained, fixed and free elements; the nature of data (dichotomous, polychotomous, polyserial correlations), PRELIS, the usefulness of standard errors, and the interpretation of LISREL output. (Handouts)

8. Exploratory and confirmatory factor analysis: issues and applications. Role of SEM in personality research, multi-trait multi-method validity studies, and in establishing the construct validity of score in academic, licensing, or other types of testing. (Handouts; Raykov & Marcoulides, Ch. 4; also, Kelloway, Ch. 5)

9. Evaluating model fit (Handouts; Raykov & Marcoulides, Ch. 2; also, Hoyle, Ch. 5, Kelloway, Ch. 3)

10. Model identification and model respecification/modification. (Raykov & Marcoulides, pp. 82-93; , Kelloway, Ch. 3)

11. Multi-trait, multi-method models. Partitioning variances to compare structural equivalence across methods. (Handouts; also, Hoyle, Ch. 10)

12. Multiple sample analysis. Comparing structural equivalence and measurement errors across racial, gender, ethnic groups or other population subgroups. (Handouts; Raykov & Marcoulides, pp. 177-196)

13. Multilevel models. Partitioning variance for nested population subgroups. (Handouts; Raykov & Marcoulides, Ch. 6)

14. Writing about structural equation models. (Handouts; also, Hoyle, Ch. 9)

During the course of the semester, we will discuss applied examples and research issues as much as possible. Please share any articles or information during class that pertain to SEM. If a new and particularly "hot topic" arises, we may spend time exploring that issue.