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COURSE SYLLABUS
CPSE 730 and IP&T 730: Multilevel Modeling
Spring Term, 2020

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INSTRUCTORS

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Office Hours: 1:00-3:00 p.m., M,W   Office Hours: 12:00 – 2:00 p.m., T, Th

CLASS MEETING SCHEDULE

The class will meet online via Zoom from 9:00-11:50 a.m. every Monday and Wednesday.

REQUIRED TEXTBOOK and COURSE PACKET

Heck, R.H., & Thomas, S.L. (2015). *An introduction to multilevel modeling techniques: MLM and SEM approaches Using Mplus*. NewYork, NY: Routledge.
Course Packet: available at the BYU Store

EXPECTED LEARNING OUTCOMES

As a result of successfully completing this course, students should be able to do the following:

1. Explain the similarities and differences between *ordinary least squares regression* and *multilevel regression* in terms of (a) the kinds of data structures that can be most appropriately be analyzed by each, (b) the kinds of research questions that can be successfully investigated by each, (c) the main features that distinguish between single-level and multilevel models, and (d) the likely consequences of using each approach when the other would have been more appropriate.
2. Understand the basic concepts used in multilevel modeling including, but not limited to the following:
    - nested units of analysis and within-level dependencies
    - estimated intercept and slope parameters and residuals
    - within-group versus between-group variance
    - intraclass correlation coefficients
    - conditional versus unconditional models
    - fixed versus random effects
    - maximum likelihood versus restricted maximum likelihood estimation
    - within-level versus cross-level interactions
    - structured versus unstructured covariance matrices
    - cross-sectional versus longitudinal designs
    - time-varying versus time-invariant predictors
3. Build and evaluate alternative models to analyze hierarchically structured data.
4. Write the set of equations for a model of interest including the correct equations at each level and the combined equations.
5. Read and interpret the equations for two- and three-level models with confidence.
6. Demonstrate proficiency in using multilevel software to analyze hierarchically structured data sets including (a) preparing the data files, (b) writing the input command files, (c) executing command files, (d) debugging syntax errors, and (e) interpreting and evaluating output files.
7. Summarize, interpret, and critique written reports of completed multilevel studies completed by other researchers.

SOFTWARE

The use of Multilevel/Hierarchical Modeling techniques is not feasible or practical without modern computers and software. General purpose statistics packages such as *SAS*, *SPSS*, and *Stata* each include specific procedures and routines that can be used to perform multilevel analyses. In addition, more specialized programs such as *Mplus*, *HLM*, and *MLWin* can also be used for this purpose. In this class we will focus on using *Mplus* to conduct multilevel analyses. Each student is expected to become proficient in using *Mplus*.

COURSE OUTLINE

The topics to be taught in this course include:
1. The nature of hierarchical data structures and the meaning of nesting
2. The limitations associated with using ordinary least squares regression models to analyze hierarchical data and the advantages of multilevel models
3. Introduction to Mplus software
4. Basic concepts and notational symbols used in multilevel models with two levels
5. Developing a general strategy for analying multilevel data
6. Preparing data files for multilevel analysis
7. Analyzing two-level models
8. Checking assumptions and assessing model-data fit
9. Strategies for building and testing alternative models
10. Analyzing models with three levels
11. Issues to consider when designing multilevel studies
12. Using multilevel models to analyze longitudinal dat
13. Alternative covariance structures
14. Conducting multilevel analyses using generalized linear models

CLASS SCHEDULE

Date	Topic and Assigned Reading	Other Activities
April 29	Introduction to the Course and software	
May 4	Chapter 1	
May 6	Chapter 2	
May 11	Chapter 3	Take home exam
May 13	Chapter 4	
May 18 & 20	Chapter 5	Assigned article review
May 25	University Holiday	
May 27 & June 1	Chapter 6	Project 1 Oral Report
June 3 & 8	Chapter 7	
June 10 & 15	Chapter 8	Project 2 or 3
June 15-18		Final Exam

GRADING POLICY

Grades will allocated based on students' performance on the homework exercises (20%), the two examinations (40%), and the two projects (40%).

COURSE PROJECTS

Each student is expected to successfully complete two of the three projects described below. All students are expected to complete Project 1. Students may choose to complete either Project 2 or Project 3.

1. Prepare a written summary and critique of a published journal article reporting the results of a research study that used multilevel modeling. The report should include a description of the purpose and context of the study plus your analysis and critique of how well multilevel modeling techniques were used in this study and to what extent the researchers' conclusions are supported by the data. Make a 10-12minute oral presentation to the class summarizing your analysis and critique of this study.

2. Analyze a multilevel data set and write a summary report which describes—
   - the purpose of the study,
   - the research questions on which the study focused,
   - how the data were obtained and analyzed,
   - the models compared, and
   - the findings and conclusions of your study.

3. Prepare a written proposal to conduct a conduct a research study using multilevel modeling techniques. The written document should include—
   - the purpose for conducting the study,
   - the research questions that you plan to investigate,
   - a brief review of relevant previous research and a rationale for why the proposed needs to be conducted,
   - the kinds of data to be analyzed and how and from source this data will be obtained,
   - the models that you expect to build and evaluate.

BYU POLICIES

Academic Honesty

The first injunction of the BYU Honor Code is the call to be honest. Students come to the university not only to improve their minds, gain knowledge, and develop skills that will assist them in their life's work, but also to build character. President David O. McKay taught that "character is the highest aim of education" (The Aims of a BYU Education, p. 6). It is the purpose of the BYU Academic Honesty Policy to assist in fulfilling that aim. BYU students should seek to be totally honest in their dealings with others. They should complete their own work and be evaluated based upon that work. They should avoid academic dishonesty and misconduct in all its forms, including but not limited to plagiarism, fabrication or falsification, cheating, and other academic misconduct.

BYU Honor Code

In keeping with the principles of the BYU Honor Code, students are expected to be honest in all of their academic work. Academic honesty means, most fundamentally, that any work you present as your own must in fact be your own work and not that of another. Violations of this principle may result in a failing grade in the course and additional disciplinary action by the university. Students are also expected to adhere to the Dress and Grooming Standards. Adherence demonstrates respect for yourself and others and ensures an effective learning and working environment. It is the university's expectation, and my own expectation in class, that each student will abide by all Honor Code standards. Please call the Honor Code Office at 422-2847 if you have questions about those standards.

Preventing Sexual Harassment

Title IX of the Education Amendments of 1972 prohibits sex discrimination against any participant in an educational program or activity that receives federal funds. The act is intended to eliminate sex discrimination in education. Title IX covers discrimination in programs, admissions, activities, and student-to-student sexual harassment. BYU's policy against sexual harassment extends not only to employees of the university, but to students as well. If you encounter unlawful sexual harassment or gender-based discrimination, please talk to your professor; contact the Equal Employment Office at 422-5895 or 367-5689 (24-hours); or contact the Honor Code Office at 422-2847.

Students with Disabilities

Brigham Young University is committed to providing a working and learning atmosphere that reasonably accommodates qualified persons with disabilities. If you have any disability which may impair your ability to complete this course successfully, please contact the Services for Students with Disabilities Office (422-2767). Reasonable academic accommodations are reviewed for all students who have qualified, documented disabilities. Services are coordinated with the student and instructor by the SSD Office. If you need assistance or if you feel you have been unlawfully discriminated against on the basis of disability, you may seek resolution through established grievance policy and procedures by contacting the Equal Employment Office at 422-5895, D-285 ASB.

PUBLISHED TUTORIALS, PRIMERS, OVERVIEWS, AND OTHER INTRODUCTORY ARTICLES

Atkins, D.C. (2005). Using multilevel models to analyze couple and family treatment data: Basic and advanced issues. *Journal of Family Psychology, 19*, 98-110.

Arnold, C.L. (1992). An introduction to hierarchical linear models. *Measurement and Evaluation in Counseling and Development, 25*, 58-90.

Ferron, J.M., Hogarty, K.Y., Dedrick, R.F., Hess, M.R., Niles, J.D. & Kromrey, J.D. (2008). Reporting results from multilevel analyses. In A.A. O'Connell & D.B. McCoach (Eds.), *Multilevel modeling of educational data* (pp. 391-426). Charlotte, NC: Information Age Publishing.

Garson, G.D. (2013). *Hierarchical linear modeling: Guide and applications*. Thousand Oaks, CA: Sage.

Glaser, D. & Hastings, R.H. (2011). An introduction to multilevel modeling for anesthesiologists. *Statistical Ground rounds, 113*, 877-887.

Goldstein, H. (2011). *Multilevel statistical models* (4th ed.). Chichester, West Sussex, UK: Wiley.

Harlow, L.L. (2014). *The essence of multivariate thinking: Basic themes and methods* (2nd ed.). New York: Routledge. [See chapter 8, "Multilevel modeling," pp. 199-201.]

Hayes, A.F. (2006). A primer on multilevel modeling. *Human Communication Research, 32*, 385-410.

Heck, R.H. (2001). Multilevel modeling with SEM. In G.A. Marcoulides & R.E. Schumacher (Eds.), *New developments and techniques in structural equation modeling* (pp. 89-127). Mahwah, NJ: Erlbaum.

Hoffman, D.A. (1997). An overview of the logic and rationale of hierarchical linear models. *Journal of Management, 23*, 723-744.

Holt, J.K. (2008). Modeling growth using multilevel and alternative approaches. In A.A. O'Connell & D.B. McCoach (Eds.), *Multilevel modeling of educational data* (pp. 111-159). Charlotte, NC: Information Age Publishing.

Kahn, J.H. (2011). Multilevel modeling: Overview and applications to research in counseling psychology. *Journal of Counseling Psychology, 58*, 257-271.

McCoach, D.B. & Black, A.C. (2008). Evaluation of model fit and adequacy. In A.A. O'Connell & D.B. McCoach (Eds.), *Multilevel modeling of educational data* (pp. 245-272). Charlotte, NC: Information Age Publishing.

McCoach, D.B. & Black, A.C. (2012). Introduction to estimation issues in multilevel modeling. *New Directions for Institutional Research, 154*, 23-39.

McCulloch, C.E. & Neuhaus, J.M. (2013). Generalized linear mixed models: Estimation and inference. In M.A. Scott, J.S. Simonoff, & B.D. Marx (Eds.), *The Sage handbook of multilevel modeling* (pp. 271-286). Thousand Oaks, CA: Sage.

McNeish, D. (2017). Small sample methods for multilevel modeling: A colloquial elucidation of REML and the Kenward-Roger correction. *Multivariate Behavioral Research, 52*, 661-670.

McNeish, D. & Kelley, K. (2019). Fixed effects models versus mixed effects models for clustered data: Reviewing the approaches, disentangling the differences, and making recommendations. *Psychological Methods, 24*(1), 20-35.

McNeish, D. & Stapleton, L.M. (2016). Modeling clustered data with very few clusters. *Multivariate Behavioral Research, 5*1, 495-518.

Mehta, P.D. & Neale, M.C. (2005). People are variables too: Multilevel structural equation modeling. *Psychological Methods, 10*, 259-284.

Morris, C.N. (1995). Hierarchical models for educational data: An overview. *Journal of Educational and Behavioral Statistics, 20*, 190-200.

Myers, N.D., Brincks, A.M., & Beauchamp, M.R. (2010). A tutorial on centering in cross-sectional two-level models. *Measurement in Physical Education and Exercise Science, 14*, 275-294.

Nezlek, J.B. (2008). An introduction to multilevel modeling for social and personality psychology. *Social and Personality Psychology Compass, 2*, 842-860.

O'Connell, A.A. & McCoach, D.B. (2004). Applications of hierarchical linear models for evaluations of health interventions: Demystifying the methods and interpretations of multilevel models. *Evaluation & the Health Professions, 27*, 119-151.

Osborne, J.W. (2008). A brief introduction to hierarchical linear modeling. In J.W. Osborne (Ed.), *Best practices in quantitative methods* (pp. 445-450). Thousand Oaks, CA: Sage.

Osborne, J.W. (2000). Advantages of hierarchical linear modeling. *Practical Assessment, Research & Evaluation, 7*(1), 1-7.

Paccagnella, O. (2006). Centering or not centering in multilevel models: The role of the group mean and the assessment of group effects. *Evaluation Review, 30*, 66-85.

Peugh, J.L. (2010). A practical guide to multilevel modeling. *Journal of School Psychology. 48*, 85-112.

Peugh, J. & Enders, C. (2005). Using the SPSS mixed procedure to fit cross-sectional and longitudinal multilevel models. *Educational and Psychological Measurement, 65*, 717-741.

Raudenbush, S.W. (1988). Educational applications of hierarchical linear model: A review. *Journal of Educational Statistics, 13*, 85-116.

Raudenbush, S.W. & Bryk, A.S. (1986). A hierarchical model for studying school effects. *Sociology of Education, 59*, 1-17.

Reise, S.P. & Duan, N. (1999). Multilevel modeling and its application in counseling psychology research. *Counseling Psychologist, 27*, 528-551.

Roberts, J.K. (2002). The importance of the intraclass correlation in multilevel and hierarchical linear modeling designs. *Multiple Linear Regression Viewpoints, 28*(2), 19-31.

Roberts, J.K. (2004). An introductory primer on multilevel and hierarchical linear modeling. *Learning Disabilities: A Contemporary Journal, 2*(1), 30-38.

Roberts, J,K. & McLeod, P. (2008). Software options for multilevel models. In A.A. O'Connell & D.B. McCoach (Eds.), *Multilevel modeling of educational data* (pp. 427-467). Charlotte, NC: Information Age Publishing.

Robson, K. & Pevalin, D. (2016). *Multilevel modeling in plain language*. Los Angeles: Sage.

Snijders, T.A.B. & Bosker, R.J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Los Angeles: Sage.

Sullivan, L.M., Dukes, K.A., & Losina, E. (1999). Tutorial in biostatistics: An introduction to hierarchical linear modeling. *Statistics in Medicine, 18*, 855-888.

Tabachnick, B.G. & Fidell, L.S. (2007). *Using multivariate statistics* (5th ed.). Boston: Pearson Allyn & Bacon. [See chapter 15, "Multilevel Linear Modeling," pp. 781-857).]

Tan, F.E.S. (2008). Best practices in analysis of longitudinal data. In J.W. Osborne (Ed.), *Best practices in quantitative methods* (pp. 451-470). Thousand Oaks, CA: Sage.

Woltman, H., Feldstain, A., MacKay, J.C., & Rocchi, M. (2012). An introduction to hierarchical linear modeling. *Tutorials in Quantitative Methods for Psychology, 8*(1), 52-69.

SUPPLEMENTARY RESOURCE MATERIALS

The following books and articles are useful supplementary materials for students who desire to examine published applications of multilevel analysis or desire to gain a more in depth understanding of specific concepts or procedures used in multilevel/hierarchical linear modeling.

Bickel, R. (2007). *Multilevel analysis for applied research: It's just regression!* New York: Guilford.

Curran, P.J. (2003). Have multilevel models been structural equation models along? *Multivariate Behavioral Research, 38*, 529-569.

Enders, C.K. & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods, 12*, 121-138.

Finch, W.H., Bolin, J.E., & Kelley, K. (2014). *Multilevel modeling using R*. Boca Raton, FL: CRC Press.

Gelman, A. & Hill, J. (2007). *Data analysis using regression and multilevel/hierarchical model*s. New York: Cambridge University Press.

Harrison, D.M. & Raudenbush, S.W. (2006). Linear regression and hierarchical linear models. In J.L. Green, G. Camilli, & P.B. Elmore (Eds.), *Handbook of complementary methods in education research* (pp. 411-426). Washington, DC: American Educational Research Association.

Heck, R.H. & Thomas, S.L. (2015). *An introduction to multilevel modeling techniques* (3rd ed.). New York: Routledge.

Hoffman, D.A. & Gavin, M.B. (1998). Centering decisions in hierarchical linear models: Implications for research in organizations. *Journal of Management, 24*, 623-641.

Hoffman, L. (2015). *Longitudinal analysis: Modeling within-person fluctuation and change*. New York, NY: Routledge.

Hox, J., Moerbeek, M., & van de Schoot, R. (2018). *Multilevel analysis: Techniques and applications* (3rd ed.). New York: Routledge.

Hox, J. & Roberts, J.K. (2010). *Handbook of advanced multilevel analysis*. New York: Routledge.

Kreft, I.G.G., de Leeuw, J., & Kim, K. (1990). The effects of different forms of centering in hierarchical linear models. *Multivariate Behavioral Research, 30*, 1-22.

Luke, D.A. (2019). *Multilevel modeling* (2nd ed.). Thousand Oaks, CA: Sage.

Nezlek, J.B. (2011). *Multilevel modeling for social and personality psychology*. Los Angeles, CA: Sage.

O' Connell, A.A. & McCoach, D.B. (Eds.) (2008). *Multilevel modeling of educational data*. Charlotte, NC: Information Age Publishing.

Preacher, K.J., Curran, P.J., & Bauer, D.J. (2006). Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics, 31*, 437-448.

Raudenbush, S.W. (1988). Educational applications of hierarchical linear models: A review. *Journal of Educational Statistics, 13*, 85-116.

Raudenbush, S.W. & Bryk, A.S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage.

Scott, M.A., Simonoff, J.S., & Marx, B.D. (Eds.) (2013). *The Sage handbook of multilevel modeling*. Los Angeles: Sage.

Singer, J.D. & Willet, J.B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York: Oxford University Press.

Skrondal, A. & Rabe-Hesketh, S. (2004). *Generalized latent variable modeling: Multilevel, longitudinal, and structural equation models*. Boca Raton, FL: Chapman & Hall.

Walls, T.A., & Schafer, J.L (Eds.) (2006). *Models for intensive longitudinal data*. New York, NY: Oxford University Pres.