Psychological and Quantitative Foundations (PSQF) 6272 Fall 2023 Section 0001: Clustered Multilevel Models

Instructor and Department Information:	**Professor Lesa Hoffman (she/her—you can call me Lesa)** Educational Measurement and Statistics Program *PSQF Dept Office: South 361 Lindquist Center; DEO: Dr. Martin Kivlighan*
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Zoom Link for Class and Instructor Office Hours:	https://uiowa.zoom.us/my/lesahoffmaniowa Meeting ID: 5044356512; Mobile Access: +13126266799 *(please use your real name as your account name to be admitted)*
Course Location and Time:	166 North Lindquist Center or via zoom Tuesdays and Thursdays 12:30–1:45 PM
Instructor Zoom-Only Office Hours:	Mondays and Wednesdays 3:30–4:30 PM in a group format or individually by appointment
Graduate Teaching Assistants' Contact Information and Office Hours:	**Nicole "Nikki" Tennessen** (she/her; PhD student in Higher Education and Student Affairs in EPLS and PhD student in Educational Measurement and Statistics in PSQF) Email: Nicole-Tennessen@UIowa.edu Tuesdays and Thursdays 2:00–3:30 PM in a hybrid format in N440 LC (old location in Center for Research on Undergraduate Education) or in a group format on zoom: https://uiowa.zoom.us/j/94348323983?pwd=a00zUFBlUWpQZlhNb1NZdUc2SkExdz09 **Cassondra "Cass" Griger** (she/her; PhD student in Educational Measurement and Statistics in PSQF); Email: Cassondra-Griger@UIowa.edu Mondays and Fridays 10:30–11:59 AM in a group format on zoom only: https://uiowa.zoom.us/j/7566081504

Schedule of Topics and Events:

T**his course will meet synchronously in person and on zoom.** The planned schedule of topics and events given here will likely need to be adjusted throughout the course. The course website will always have the most current schedule of events and due dates: http://www.lesahoffman.com/PSQF6272/index.html

Course Objectives, Pre-Requisites, and Materials:

This course will illustrate the uses of multilevel models (i.e., general linear mixed-effect models, hierarchical linear models) for the analysis of clustered data (i.e., persons nested in natural groups). The course objective is for participants to be able to complete all the necessary steps in a multilevel analysis: deciding which type of model is appropriate, organizing the analysis data and creating predictor variables, testing fixed and random effects, predicting multiple sources of variation, and interpreting and presenting empirical findings.

Participants should already be comfortable with general linear models (e.g., regression, ANOVA), which can be reviewed using the PSQF 6243 materials. Ideally participants should also be familiar with generalized linear models (e.g., logistic regression, count regression), which can be reviewed using the PSQF 6270 materials.

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Class time will be devoted primarily to lectures, examples, and spontaneous review, the materials for which will be available for download at the course website. Readings and other resources have been suggested for each topic and may be updated later. Synchronous attendance (in person or via zoom) is encouraged but not required, and you do not need to notify the instructor of a single class absence. Video recordings of each class will be made available on YouTube so that closed captioning will be provided, and supplemental videos for specific topics (e.g., software demos) may be added as well. Auditors and visitors are always welcome to attend class. No required class sessions will be held outside the regular class time given above (i.e., no additional midterm or final exam sessions). However, because the course will have an applied focus requiring the use of statistical software, participants are encouraged to attend group-based office hours (via zoom only), in which multiple participants can receive immediate assistance on homework assignments simultaneously.

Course Requirements:

Course participants will have the opportunity to earn up to **100 total points** by completing work outside of class. Up to **88 points** can be earned from submitting homework assignments (approximately 6 in total) through a custom online system or ICON—these will be graded for accuracy. Homework assignments that involve individual writing can be revised once to earn the maximum total points; these **written assignments must be at least ¾ complete to be accepted**. Unless otherwise instructed, please use "track changes" and retain all original instructor comments (you may mark them as "resolved" but please don't delete them) so that the instructor can easily see how your revisions address the comments. Up to **12 points** may be earned from submitting **formative assessments** (approximately 6 in total) through ICON; these will be graded for effort only—incorrect answers will not be penalized. Participants may earn up to **2 extra credit points** for completing homework 0; there may be other opportunities to earn extra credit at the instructor's discretion. Finally, revisions to the planned course schedule and/or content may result in fewer homework assignments and formative assessments (and thus fewer total points) at the instructor's discretion.

Revision to Course Requirements as of 9/28/23 (points corrected 11/29/23):

Due to schedule compression, there will only be 5 homework assignments (instead of 6) worth **76 points**. There will still be 12 points to be earned from formative assessments. Consequently, there will be **88 possible points in total from homework assignments and formative assessments**.

Policy on Accepting Late Work and Grades of Incomplete:

Participants may submit work at any point during the semester to be counted towards their course grade. However, in order to encourage participants to keep up with the class, **late homework (HW) assignments will incur a 2-point penalty, and late HW plans, HW written revisions, or formative assessments will incur a 1-point penalty** (overall, not per day) Extensions will be granted as needed for extenuating circumstances (e.g., conferences, comprehensive exams, family obligations) if requested at least two weeks in advance of the due date. A final grade of "incomplete" will only be given in dire circumstances and entirely at the instructor's discretion. **All work must be submitted by Friday, December 15, 2023, at 5:00 PM to be included in the course grade.**

Final grades will be determined by the *percentage* earned out of the total possible points:

>96% = A+, 93–96% = A, 90–92% = A−, 87–89% = B+, 83–86% = B, 80–82% = B−, 77–79% = C+, 73–76% = C, 70–72% = C− **(PASS)**, 67–69% = D+, 63–66% = D, 60–62% = D−, <60% = F

Course Software:

Participants will need to have access to statistical software—**STATA or R+Rstudio**—that can estimate the models presented. Each of these programs is freely available to participants in multiple ways:

- You can connect to the U Iowa Virtual Desktop (connect to the U Iowa VPN first) for free

- You can connect to the U Iowa Research Remote Desktop (connect to the U Iowa VPN first) for free

- You can install R software for free on your local machine, along with the free graphical Rstudio interface that makes R easier to use (install second after R software)

- You could also pay $48 to install a 6-month student copy of STATA on your local machine

M*plus* software may also be used for multivariate multilevel models (time permitting), which will be made available to course participants through the U Iowa Virtual Desktop (connect to the U Iowa VPN first) for free.

Recommended Course Textbook (to be purchased separately):

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

Other Course Readings (available via "Files" in ICON):

Arend, M. G., & Schäfer, T. (2019). Statistical power in two-level models: A tutorial based on Monte Carlo simulation. *Psychological Methods, 24*(1), 1–19. https://doi.org/10.1037/met0000195

Bauer, D. (2009). A note on comparing the estimates of models for cluster-correlated or longitudinal data with binary or ordinal outcomes. *Psychometrika, 74*(1), 97–105. https://doi.org/10.1007/s11336-008-9080-1

Brincks, A. M., Enders, C. K., Llabre, M. M., Bulotsky-Shearer, R. J., Prado, G., & Feaster, D. J. (2017). Centeirng predictor variables in three-level contextual models. *Multivariate Behavioral Research, 52*(2), 149–163. https://doi.org/10.1080/00273171.2016.1256753

De Boeck, P., Bakker, M., Zwitser, R., Nivard, M., Hofman, A., Tuerlinckx, F., & Partchev, I. (2011). The Estimation of Item Response Models with the lmer Function from the lme4 Package in R. *Journal of Statistical Software, 39*(12), 1–28. https://doi.org/10.18637/jss.v039.i12

Enders, C. K. (2010; chapters 3–5). *Applied missing data analysis* (1st ed). Guilford.

Hamaker, E. L., & Muthén, B. (2020). The fixed versus random effects debate and how it relates to centering in multilevel modeling. *Psychological Methods, 25*(3), 365–379. https://doi.org/10.1037/met0000239

Hoffman, L. (2015). *Longitudinal analysis: Modeling within-person fluctuation and change*. Routledge/Taylor & Francis.

Hoffman, L. (2019). On the interpretation of parameters in multivariate multilevel models across different combinations of model specification and estimation. *Advances in Methods and Practices in Psychological Science, 2*(3), 288–311. https://doi.org/10.1177%2F2515245919842770

Hoffman, L., & Walters, R. W. (2022). Catching up on multilevel modeling. *Annual Review of Psychology, 73*, 629-658. https://doi.org/10.1146/annurev-psych-020821-103525

Hox, J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed). Routledge.

Lester, H. F., Cullen-Lester, K. L., & Walters, R. W. (2021). From nuisance to novel research questions: Using multilevel models to predict heterogeneous variances. *Organizational Research Methods, 24*(4), 342–388. https://doi.org/10.1177%2F1094428119887434

Loeys, T., Josephy, H., & Dewitte, M. (2018). More precise estimation of lower-level interaction effects in multilevel models. *Multivariate Behavioral Research, 53*(3), 335-347. https://doi.org/10.1080/00273171.2018.1444975

Lüdtke, O., Marsh, H. W., Robitzsch, A., Trautwein, U., Asparouhov, T., & Muthén, B. (2008). The multilevel latent covariate model: A new, more reliable approach to group-level effects in contextual studies. *Psychological Methods, 13*(3), 203–229. https://doi.org/10.1037/a0012869

Lüdtke, O., Marsh, H. W., Robitzsch, A., & Trautwein, U. (2011). A 2 × 2 taxonomy of multilevel latent contextual models: Accuracy–bias trade-offs in full and partial error correction models. *Psychological Methods, 16*(4), 444–467. https://doi.org/10.1037/a0024376

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McNeish, D. (2017). Small sample methods for multilevel modeling: A colloquial elucidation of REML and the Kenward-Roger correction. *Multivariate Behavioral Research, 52*(5), 661–670. https://doi.org/10.1080/00273171.2017.1344538

McNeish, D. (2023). *A practical guide to selecting (and blending) approaches for clustered data: Clustered errors, multilevel models, and fixed effect models.* Under review. https://osf.io/w4x9n/

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. https://doi.org/10.1037/met0000182

Nakagawa S., Johnson P. C. D., & Schielzeth H. (2017). The coefficient of determination R^2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. *Journal of the Royal Society Interface, 14*(134), 20170213. http://dx.doi.org/10.1098/rsif.2017.0213

Nakagawa, S., & Schielzeth, H. (2010). Repeatability for Gaussian and non-Gaussian data: A practical guide for biologists. *Biological Reviews, 85*, 935–956. https://doi.org/10.1111/j.1469-185X.2010.00141.x

O'Keefe, P., & Rodgers, J. L. (2017). Double decomposition of level-1 variables in multilevel models: An analysis of the Flynn Effect in the NSLY data. *Multivariate Behavioral Research, 52*(5), 630–647. https://doi.org/10.1080/00273171.2017.1354758

Preacher, K. J., Zhang, Z., & Zyphur, M. J. (2011). Alternative methods for assessing mediation in multilevel data: The advantages of multilevel SEM. *Structural Equation Modeling, 18*(2), 161–182. https://psycnet.apa.org/doi/10.1080/10705511.2011.557329

Preacher, K. J., Zhang, Z., & Zyphur, M. J. (2016). Multilevel structural equation models for assessing moderation within and across levels of analysis. *Psychological Methods, 21*(2), 189–205. https://doi.org/10.1037/met0000052

Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods, 15*(3), 209–233. https://doi.apa.org/doi/10.1037/a0020141

Rights, J. D., & Sterba, S. K. (2019). Quantifying explained variance in multilevel models: An integrative framework for defining R-squared measures. *Psychological Methods, 24*(3), 309–338. https://doi.org/10.1037/met0000184

Rights, J. D., & Sterba, S. K. (2020). New recommendations on the use of R-squared differences in multilevel model comparisons. *Multivariate Behavioral Research, 55*(4), 568–599. https://doi.org/10.1080/00273171.2019.1660605

Rights, J, D., & Sterba, S. K. (in press). On the common but problematic specification of conflated random slopes in multilevel models. *Multivariate Behavioral Research*. Advance online publication. https://doi.org/10.1080/00273171.2023.2174490

Rijmen, F., Tuerlinckx, F., De Boeck, P., & Kuppens, P. (2003). A nonlinear mixed model framework for item response theory. *Psychological Methods, 8*(2), 185–205. https://psycnet.apa.org/doi/10.1037/1082-989X.8.2.185

Stoel, R. D., Garre, F. G., Dolan, C., & van den Wittenboer, G. (2006). On the likelihood ratio test in structural equation modeling when parameters are subject to boundary constraints. *Psychological Methods, 11*(4), 439–455. https://doi.org/10.1037/1082-989X.11.4.439

ten Hove, D., Jorgensen, T. D., & van der Ark, L. A. (2022). Interrater reliability for multilevel data: A generalizability theory approach. *Psychological Methods, 27*(4), 650–666. https://doi.org/10.1037/met0000391

Yaremych, H. E., Preacher, K. J., & Hedeker, D. (2023). Centering categorical predictors in multilevel models: Best practices and interpretation. *Psychological Methods, 28*(3) 613–630. http://dx.doi.org/10.1037/met0000434

Academic Misconduct:

As a reminder, the University of Iowa College of Education has a [formal policy on academic misconduct](#), which all students in this course are expected to follow. While students can work with each other to understand the course content, all homework assignments must ultimately be completed individually. Please consult the instructor if you have any questions.

Respect for Each Other:

The instructor wants ALL students to feel welcome and encouraged to participate in this course. **There is no such thing as a "stupid" question (or answer).** All course participants—enrolled students and auditing visitors—should always feel welcome to ask whatever questions will be helpful in helping them understand the course content. **Questions or comments are welcome at any point:** during class (aloud or using the zoom chat window), in office hours, over email, or in individual appointments with the instructor (available by request). Students with disabilities or who have any other special needs are encouraged to contact the instructor for a confidential discussion of their individual considerations for academic accommodation.

All participants are welcome to attend class via zoom instead of in person for any reason at any time. If it possible that you have been exposed to COVID-19 or any other illness, please DO NOT attend class in person! Similarly, if the instructor has been exposed to illness or the weather prohibits safe travel to class, the course will move to a temporary zoom-only format to protect all course participants.

When using zoom, please provide the name you wish for us to call you inside your zoom account (i.e., so that it appears on your window while in use). Student use of cameras and microphones while on zoom is also encouraged but not required (out of respect for your privacy and/or limited bandwidth). Please note that class video recordings posted on YouTube will NOT include any video from course participants (only the class audio and screen share from the instructor will be captured). Participants who do not wish for their audio to be captured can use the zoom chat window (which also allows for private direct messages to the instructor), even while attending in person.

The University of Iowa is committed to **making the class environment (in person or online) a respectful and inclusive space** for people of all gender, sexual, racial, religious, and other identities. Toward this goal, students are invited to optionally share the names and pronouns they would like their instructors to use to address them. The University of Iowa prohibits discrimination and harassment against individuals on the basis of race, class, gender, sexual orientation, national origin, and other identity categories. For more information, contact the [Office of Institutional Equity](#). Additional university guidelines about classroom behavior and other student resources [are provided here](#), student complaint procedures [are provided here](#), and the university acknowledgement of land and sovereignty [is provided here.](#)

Respect for the Rest of Your World:

The instructor realizes that this course is not your only obligation in your work or your life. If work or life events (expected or unexpected) may compromise your ability to succeed in this course, PLEASE contact the instructor for a confidential discussion (in person or over email, as you prefer) so that we can work together to make a plan for your success. **Please do not wait to do so until you are too far behind to catch up!**

Last updated 12/5/2023

Schedule of Events (Weeks 1–8):

Week	Weekday and Date		Topics and Course Materials	Readings for Each Topic (not just that day)
1	M	8/21	**NO OFFICE HOURS MON 8/21; NO HOMEWORK (HW) OR FORMATIVE ASSESSMENTS (FA) DUE**	
	T	8/22	Lecture 1: Introduction to this Course and to Multilevel Models (MLMs) for Clustered Data	S & B (2012) ch. 1–2 Hoffman & Walters (2022)
	R	8/24	Lecture 2 and Example 2: From Empty Models to Level-2 Predictors in General MLMs for Two-Level Nested Data	S & B (2012) ch. 3–4 McNeish (2017)
2	M	8/28	**HW0 (2 points extra credit) DUE ONLINE BY 11:59 PM FA1 DUE VIA ICON BY 11:59 PM**	
	T	8/29	**MEET ON ZOOM ONLY** Discussion of FA1; Lecture 2 and Example 2, continued	
	R	8/31	**MEET ON ZOOM ONLY** Lecture 2 and Example 2, continued	
3	M	9/4	**NO OFFICE HOURS MON 9/4; NO HW OR FA DUE**	
	T	9/5	Lecture 2 and Example 2, continued	Rights & Sterba (2019, 2020) Yaremych et al. (2023)
	R	9/7	**MEET ON ZOOM ONLY** Lecture 3 and Example 3: Fixed Slopes of Level-1 Predictors in General MLMs for Two-Level Nested Data	
4	M	9/11	**NO HW OR FA DUE**	
	T	9/12	Lecture 3, continued	Hamaker & Muthén (2020) McNeish & Kelley (2019) McNeish (2023)
	R	9/14	**HW1 (based on Example 2) DUE !!! WED 9/13 !!! ONLINE BY 11:59 PM** Lecture 3 and Example 3, continued	
5	M	9/18	**FA2 DUE VIA ICON BY 11:59 PM**	
	T	9/19	Discussion of FA2 Lecture 3 and Example 3, continued	
	R	9/21	Lecture 3 and Example 3, continued	
6	M	9/25	**NO HW OR FA DUE**	
	T	9/26	Lecture 4: Random Slopes and Cross-Level Interactions in General MLMs for Two-Level Nested Data	S & B (2012) ch. 5–6 Rights & Sterba (in press) Enders (2010) ch. 3–5 Stoel et al. (2006)
	R	9/28	**HW2 (based on Example 3) DUE !!! WED 9/27 !!! ONLINE BY 11:59 PM** Lecture 4, continued	
7	M	10/2	**FA3 DUE VIA ICON BY 11:59 PM**	
	T	10/3	Discussion of FA3; Lecture 4, continued	
	R	10/5	Lecture 4 and Example 4, continued	
8	M	10/9	**NO HW OR FA DUE**	
	T	10/10	Lecture 4, continued Example 4: Random Slopes and Cross-Level Interactions in General MLMs for Two-Level Nested Data	
	R	10/12	**NO OFFICE HOURS WED 10/11; NO CLASS THURS 10/12**	

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Schedule of Events (Weeks 9–15):

Week	Weekday and Date		Topics and Course Materials	Readings for Each Topic (not just that day)
9	M	10/16	**HW4 PLAN DUE VIA ICON BY 11:59 PM**	
	T	10/17	Lecture 4 and Example 4, continued	
	R	10/19	Lecture 4 and Example 4, continued	
10	M	10/23	**FA4 DUE VIA ICON BY 11:59 PM**	
	T	10/24	Discussion of FA4 Lecture 5: General MLMs for Two-Level Cross-Classified Data Example 5: Two-Level Crossed Schools Bonus Example: Subjects Crossed with Items Bonus Example: Changes in Nesting over Time	S & B (2012) ch. 13 ten Hove et al. (2022) O'Keefe & Rodgers (2017) Hoffman (2015) ch. 12
	R	10/26	**MEET ON ZOOM ONLY** Lecture 5 and Example 5a, continued	
11	M	10/30	**HW3 (based on Example 4) DUE ONLINE BY 11:59 PM**	
	T	10/31	Lecture 5 and Example 5, continued	
	R	11/2	Lecture 6: Generalized MLMs for Two-Level Nested Data Example 6a: MLM for Clustered Binary Outcomes	Hox (2010) ch. 6–7 S & B (2012) ch. 10, 1 Bauer (2009)
12	M	11/6	**FA5 DUE VIA ICON BY 11:59 PM**	
	T	11/7	Discussion of FA5 Lecture 6 and Example 6a, continued	
	R	11/9	Lecture 6 and Example 6a, continued	
13	M	11/13	**HW4 DUE VIA ICON BY 11:59 PM: Individual Analysis of Clustered Data or AI Correction**	
	T	11/14	Lecture 6 and Example 6a, continued	Nakagawa & Schielzeth (2010) Nakagawa et al. (2017)
	R	11/16	Lecture 6 and Example 6a, continued Example 6b: MLM for Clustered Count Outcomes	
14	M	11/20	**NO HW OR FA DUE**	
	T	11/21	**NO OFFICE HOURS MON 11/20 OR CLASS TUES 11/21**	
	R	11/23	**NO OFFICE HOURS WED 11/22 OR CLASS THURS 11/23**	
15	M	11/27	**NO HW OR FA DUE**	
	T	11/28	Lecture 7 and Example 7: Generalized MLMs for Subjects Crossed with Items (Explanatory Item Response Theory)	Rijmen et al. (2003) De Boeck et al. (2011)
	R	11/30	Lecture 7 and Example 7, continued	

Schedule of Events (Weeks 16–17):

Week	Weekday and Date		Topics and Course Materials	Readings for Each Topic (not just that day)
16	M	12/4	**FA6 DUE VIA ICON BY 11:59 PM**	
	T	12/5	Lecture 8: Multivariate Multilevel Models and Three-Level Models Example 8a:Multivariate Multilevel Models in Mplus	Lüdtke et al. (2008; 2011) Hoffman (2019) McNeish (2017) Preacher et al. (2010, 2011, 2016)
	R	12/7	Lecture 8 and Example 8a, continued Example 8b: Three-Level Nested Models	Hoffman (2015) ch. 11 Brincks et al. (2011)
			Bonus Readings: Location-Scale Models and Power Analysis for MLMs	Lester et al. (2021) S & B (2012) ch. 8
			SUBMIT HW4 BY FRIDAY 12/8 FOR A GUARANTEED REVISION OPPORTUNITY	Arend & Schäfer (2019) Hoffman (2015) ch. 13
17	M	12/11	**NO HW OR FA DUE; OFFICE HOURS 3:30-4:30 PM**	
	T	12/12	**NO CLASS, BUT OFFICE HOURS 12:30-2:00 PM**	
	W	12/13	**OFFICE HOURS 3:30-4:30 PM**	
	R	12/14	**NO CLASS, BUT OFFICE HOURS 12:30-2:00 PM**	
	F	12/15	**HW5/6 (Example TBD) DUE ONLINE BY 5:00 PM ONLINE:** **HW5 using STATA or HW6 using R** **HW4 REVISIONS DUE VIA ICON BY 5:00 PM** **ALL OUTSTANDING WORK DUE BY 5:00 PM**	

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