Psychological and Quantitative Foundations (PSQF) 6249 Section 0002: Factor Analysis and Structural Equation Models Spring 2024

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*
Instructor Contact Information:	Email: Lesa-Hoffman@UIowa.edu *(preferred mode of contact)* Office: 356 South Lindquist Center *(mostly unattended)* Phone: 319-384-0522 *(mostly unattended)*
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 2:00–3:15 PM
Instructor Office Hours:	Mondays and Wednesdays 3:00–4:30 PM in an online group format via zoom or individually by appointment
Graduate Teaching Assistants' Contact Information and Office Hours:	**Cassondra "Cass" Griger** (she/her) PhD candidate in Educational Measurement and Statistics in PSQF Email: Cassondra-Griger@UIowa.edu Office hours in an online group format: Mondays 12:30-2:00 PM and Thursdays 3:30-5:00 PM via zoom: https://uiowa.zoom.us/j/7566081504 **Geraldo "Bladimir" Padilla** (he/him) PhD student in Educational Measurement and Statistics in PSQF Email: Geraldo-Padilla@UIowa.edu Office Hours in a hybrid group format: Tuesdays and Thursdays 9:00–11:59 AM in N476 LC or via zoom: https://uiowa.zoom.us/j/7961502515

Schedule of Topics and Events:

This 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/PSQF6249/index.html

Course Objectives, Prerequisites, and Materials:

The course objective is for participants to be able to understand and implement contemporary approaches to measurement, expanding from classical test theory into measurement models for latent traits (i.e., confirmatory factor models, item response models) and their use within structural equation models. In addition to these statistical models, the course will also focus on the measurement concepts behind these models and how they relate to each other with respect to scale construction and evaluation.

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.

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 simultaneously or sequentially.

Course Requirements:

Participants can earn up to **100 total points** by completing work outside of class. Up to **90 points** can be earned from **homework assignments** (6 initially planned) through a custom online system or ICON—these will be graded for accuracy. Homework assignments that involve **individual writing** will have the opportunity to be **revised once** to earn the maximum points. **Written assignments must be at least ¾ complete to be accepted**. Unless otherwise instructed, please use "track changes" and retain all original instructor comments so that the instructor can easily see how your revisions address the comments.

Up to **10 points** may be earned from submitting **formative assessments** (5 initially planned) 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.

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 assignments will incur a 2-point penalty; late revisions or late 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, May 10, 2024, 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—**M*plus* or R+Rstudio**—that can estimate the models presented. Each of these programs are freely available to course participants in multiple ways:

- You can connect to the U Iowa Virtual 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 $195 for a student license for the base version of M*plus*

Course Textbook:

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd ed). Guilford. Available at the University of Iowa library in electronic form and in ICON under "Files" by chapter.

Last updated 1/16/2024

Other Course Readings (all available in ICON under "Files"):

Note—I know this is A LOT of readings, but we are covering a lot of material! I have included these sources to give you some additional background and/or exposure to current best-practices in each topic. I encourage you to read as much as possible, but your priority should be to participate in class and complete course work first!

Asparouhov, T. & Muthén, B. (2014) Multiple-group factor analysis alignment. *Structural Equation Modeling, 21*(4), 495–508. https://doi.org/10.1080/10705511.2014.919210

Bandalos, D. L. (2021). Item meaning and order as causes of correlated residuals in confirmatory factor analysis. *Structural Equation Modeling, 28*(6), 903–913. https://www.tandfonline.com/doi/full/10.1080/10705511.2021.1916395

Bauer, D. J., & Hussong, A. M. (2009). Psychometric approaches for developing commensurate measures across independent studies: Traditional and new models. *Psychological Methods, 14*(2), 101–125. https://psycnet.apa.org/doi/10.1037/a0015583

Bollen, K. A., & Diamantopoulos, A. (2017). In defense of causal-formative indicators: A minority report. *Psychological Methods, 22*(3), 581–596. https://psycnet.apa.org/doi/10.1037/met0000056

Chen, F., F., West, S. G., & Sousa, K. H. (2006). A comparison of bifactor and second-order models of quality of life. *Multivariate Behavioral Research, 41*(2), 189–225.

Clifton, J. D. W. (2020). Managing validity versus reliability trade-offs in scale-building decisions. *Psychological Methods, 25*(3), 259–270. https://doi.org/10.1037/met0000236

Cole, D. A., & Preacher, K. J. (2014). Manifest variable path analysis: potentially serious and misleading consequences due to uncorrected measurement error. *Psychological Methods, 19*(2), 300–315. https://psycnet.apa.org/doi/10.1037/a0033805

Curran, P. J. Cole, V. T., Bauer, D. J., Rothenberg, W. A., & Hussong, A. M. (2018). Recovering predictor–criterion relations using covariate-informed factor score estimates. *Structural Equation Modeling, 25*(6), 860–875. https://doi.org/10.1080%2F10705511.2018.1473773

Curran, P. J., McGinley, J. S., Bauer, D. J., Hussong, A. M., Burns, A., Chassin, L., Sher, K., & Zucker, R. (2014). A moderated nonlinear factor model for the development of commensurate measures in integrative data analysis. *Multivariate Behavioral Research, 49*(3), 214–231. https://doi.org/10.1080/00273171.2014.889594

Davidson, C. A., Hoffman, L., & Spaulding, W. D. (2016). Schizotypal personality questionnaire – brief revised (updated): An update of norms, factor structure, and item content in a large non-clinical young adult sample. *Psychiatry Research, 238*, 345–355. https://doi.org/10.1016/j.psychres.2016.01.053

Edwards, M. C., & Wirth, R. J. (2009). Measurement and the study of change. *Research in Human Development, 62*(2–3), 74–96. https://psycnet.apa.org/doi/10.1080/15427600902911163

Embretson, S. E., & Reise, S. T. (2000). *Item response theory for psychologists*. Erlbaum.

Enders, C. K. (2010). *Applied missing data analysis*. Guilford.

Feng, Y., & Hancock, G. R. (2023). Power analysis within a structural equation modeling framework. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2nd ed.), pp. 163–183. Guildford.

Ferrando, P. J. (2009). Difficulty, discrimination, and information indices in the linear factor analysis model for continuous item responses. *Applied Psychological Measurement, 33*(1), 9–24. https://doi.org/10.1177%2F0146621608314608

Gonzales, O., Valente, M. J., Cheong, J., & MacKinnon, D. P. (2023). Mediation/indirect effects in structural equation modeling. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2nd ed.), pp. 409–426. Guildford.

Gunn, H. J., Grimm, K. J., & Edwards, M.C. (2020). Evaluation of six effect size measures of measurement non-invariance for continuous outcomes. *Structural Equation Modeling, 27*(4), 503–514. https://doi.org/10.1080/10705511.2019.1689507

Henninger, M., & Meiser, T. (2020). Different approaches to modeling response styles in divide-by-total item response theory models (part 1): A model integration. *Psychological Methods, 25*(5), 560–576. https://doi.org/10.1037/met0000249

Henninger, M., & Meiser, T. (2020). Different approaches to modeling response styles in divide-by-total item response theory models (part 2): Applications and novel extensions. *Psychological Methods, 25*(5), 577–595. https://doi.org/10.1037/met0000268

Huggins-Manley, A. C., Algina, J. & Zhou, S. (2018). Models for semiordered data to address not applicable responses in scale measurement. *Structural Equation Modeling, 25*(2), 230–243. https://doi.org/10.1080/10705511.2017.1376586

John, O. P., & Benet-Martinez, V. (2014). Measurement: Reliability, construct validation, and scale construction. In H. T. Reis & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 473-503, 2nd ed.). Cambridge University Press.

Magnus, B. E., & Liu, Y. (2022). Symptom presence and symptom severity as unique indicators of psychopathology: An application of multidimensional zero-inflated and hurdle graded response models. *Educational and Psychological Measurement, 82*(5), 938–966. https://doi.org/10.1177/00131644211061820

Maydeu-Olivares, A. (2015). Evaluating the fit of IRT models. In S. P. Reise & D. A. Revicki (Eds.), *Handbook of item response theory modeling* (pp. 111–127). Taylor & Francis.

McDonald, R. P. (1999). *Test theory: A unified treatment*. Erlbaum.

McNeish, D. (2018). Thanks coefficient alpha, we'll take it from here. *Psychological Methods, 23*(3), 412–433. https://doi.org/10.1037/met0000144

McNeish, D. & Wolf, M G. (2020). Thinking twice about sum scores. *Behavior Research Methods, 52*(6), 2287–2305. https://doi.org/10.3758/s13428-020-01398-0

Mungas, D., & Reed, B. R. (2000). Application of item response theory for development of a global functioning measure of dementia with linear measurement properties. *Statistics in Medicine, 19*(11–12), 1631–1644. https://doi.org/10.1002/(sici)1097-0258(20000615/30)19:11/12%3C1631::aid-sim451%3E3.0.co;2-p

Ostini, R., & Nering, M. (2006). *Polytomous item response theory models.* Sage. Available at the University of Iowa library in electronic form.

Paek, I., Cui, M., Gübes, N. O., & Yang, Y. (2018). Estimation of an IRT model by Mplus for dichotomously scored responses under different estimation methods. *Educational and Psychological Measurement*, *78*(4), 569–588. https://doi.org/10.1177%2F0013164417715738

Preacher, K. J., & MacCallum, R. C. (2003). Repairing Tom Swift's electric factor analysis machine. *Understanding Statistics, 2*(1), 13–43. https://doi.org/10.1207/S15328031US0201_02

Reise, S. P., Mansolf, M. & Haviland, M. G. (2023). Bifactor measurement models. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2nd ed.), pp. 329–348. Guildford Press.

Revuelta, J., Maydeu-Olivares, A., & Ximénez, C. (2020). Factor analysis for nominal (first choice) data. *Structural Equation Modeling, 27*(5), 781–797. https://psycnet.apa.org/doi/10.1080/10705511.2019.1668276

Rohrer, J. M., Hünermund, P., Arslan, R. C., & Elson, M. (2022). That's a lot to process! Pitfalls of popular path models. *Advances in Methods and Practices in Psychological Science, 5*(2), 1–14. https://doi.org/10.1177%2F25152459221095827

Sterba, S. K., & Rights, J. D. (2023). Item parceling in SEM: A researcher degree-of-freedom ripe for opportunistic use. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2nd ed.), pp. 296–315. Guildford.

Tay, L., & Jebb, A. T. (2018). Establishing construct continua in construct validation: The process of continuum specification. *Advances in Methods and Practices in Psychological Science*, *1*(3), 375–388. https://doi.org/10.1177%2F2515245918775707

Vandenberg, R. J., & Lance, C. E. (2000). A review and synthesis of the measurement invariance literature: Suggestions, practices, and recommendations for organizational research. *Organizational Research Methods, 3*(1), 4–69. https://doi.org/10.1177%2F109442810031002

West, S. G., Wu, W., McNeish, D., & Savord, A. (2023). Model fit in structural equation modeling. In R. H. Hoyle (Ed.) *Handbook of structural equation modeling* (2nd ed.), pp. 184–285. Guildford.

Wirth, R. J., & Edwards, M. C. (2007). Item factor analysis: Current approaches and future directions. *Psychological Methods, 12*(1), 58–79. https://doi.org/10.1037/1082-989x.12.1.58

Zhang, X., Zhou, L., & Savalei, V. (2022). Comparing the psychometric properties of a scale across three likert and three alternative formats: An application to the Rosenberg Self-Esteem Scale. Online advance publication in *Educational and Psychological Measurement*. https://doi.org/10.1177/00131644221111402

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 course activities must ultimately be completed individually. Please consult the instructor if you have 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 is 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. While class attendance in real time is not mandatory, it is strongly encouraged because frequent review of the material will be your best strategy for success in this course. However, if work or life events may compromise your ability to succeed, please contact the instructor for a confidential discussion so that we can work together to make a plan for your success. **Please do not wait until you are too far behind to try to catch up!**

Planned Schedule of Events for Weeks 1–7:

Week Number	Weekday and Date		Topics	Readings and Resources for Each Topic
1	M	1/15	**NO OFFICE HOURS TODAY; NO HOMEWORK (HW) OR FORMATIVE ASSESSMENT (FA) DUE**	
	T	1/16	**MEET ON ZOOM ONLY** Lecture 1: Introduction to this Course and to Latent Trait Measurement Models	Brown (2015) ch. 1 John & Benet-Martinez (2014)
	R	1/18	Lecture 1, continued	
			Bonus material: Lecture 2 and videos from the previous version of this class; Lecture videos for PCA and EFA by Jonathan Templin (under "Files" in ICON)	Brown (2015) ch. 2 Preacher & McCollum (2003)
2	M	1/22	**NO HW OR FA DUE**	
	T	1/23	Lecture 1, continued Lecture 3: Classical Test Theory for Scale Reliability	McDonald (1999) ch. 5-7
	R	1/25	Lecture 3, continued Example 3: Classical Items Analysis	McNeish (2018) Clifton (2020)
3	M	1/29	**HW0 (for 2 points extra credit) DUE ONLINE BY 11:59 PM**	
	T	1/30	Lecture 4: Confirmatory Factor Analysis	Brown (2015) ch. 3-5
	R	2/1	Lecture 4, continued	Ferrando (2009) West et al. (2023)
4	M	2/5	**FA1 DUE VIA ICON BY 11:59 PM**	
	T	2/6	Discussion of FA1; Lecture 4, continued Example 4: Confirmatory Factor Models in Mplus (and SAS MIXED)	McNeish & Wolf (2020)
	R	2/8	Lecture 4 and Example 4, continued	Bollen & Diamantopoulos (2017)
5	M	2/12	**HW1 DUE VIA ICON BY 11:59 PM: Instrument Background**	
	T	2/13	Lecture 4 and Example 4, continued	Enders (2010) ch. 3-5
	R	2/15	Lecture 4 and Example 4, continued	
6	M	2/19	**FA2 DUE VIA ICON BY 11:59 PM**	
	T	2/20	Discussion of FA2; Lecture 4 and Example 4, continued	
	R	2/22	Lecture 4 and Example 4, continued	
7	M	2/26	**NO HW OR FA DUE**	
	T	2/27	Lecture 5: Latent Trait Measurement Models for Binary Responses	Embretson & Reise (2000) ch. 2-4, 7-8 Mungas & Reed (2000)
	R	2/29	Lecture 5, continued	Wirth & Edwards (2007)

Last updated 1/16/2024

Planned Schedule of Events for Weeks 8–12:

Week Number	Weekday and Date		Topics	Readings and Resources for Each Topic
8	M	3/4	**HW2 DUE ONLINE BY 11:59 PM: Practice with CTT and CFA**	
	T	3/5	Lecture 5, continued Example 5: Binary Item Response Models in Mplus	Maydeu-Olivares (2015) Paek et al. (2018)
	R	3/7	Lecture 5 and Example 5a, continued	
9	M	3/11	**NO HW OR FA DUE**	
	T	3/12	**NO CLASS OR OFFICE HOURS THIS WEEK**	
	R	3/14	**NO CLASS OR OFFICE HOURS THIS WEEK**	
10	M	3/18	**FA3 DUE VIA ICON BY 11:59 PM** **OPTIONAL REVISION TO HW1 DUE VIA ICON BY 11:59 PM**	
	T	3/19	Discussion of FA3; Lecture 5 and Example 5a, continued	
	R	3/21	Lecture 5 and Example 5, continued	
11	M	3/25	**HW3 DUE VIA ICON BY 11:59 PM: CTT and CFA on Your Own Data**	
	T	3/26	Lecture 6: Latent Trait Measurement Models for Other Item Responses Example 6a: Graded Response Models for Ordinal Responses in Mplus	Embretson & Reise (2000) ch. 5 Brown (2015) ch. 9 Ostini & Nering (2011)
	R	3/28	**MEET ON ZOOM ONLY** Lecture 6 and Example 6a, continued Bonus material from a previous class: Example 6b: Measurement Models for Semi-Ordered (Not Applicable) Responses in Mplus Example 6c: Measurement Models for Other Non-Normal Outcomes in Mplus	 Huggins-Manley et al. (2018) Revuelta et al. (2020) Bauer & Hussong (2009) Magnus & Liu (2021)
12	M	4/1	**FA4 DUE VIA ICON BY 11:59 PM**	
	T	4/2	Discussion of FA4; Lecture 6 and Example 6a, continued	
	R	4/4	Lecture 7: Measurement Invariance in CFA and Differential Item Functioning in IRT/IFA	Brown (2015) ch. 7 Vandenberg & Lance (2000) Gunn et al. (2020) Asparouhov & Muthén (2014)

Planned Schedule of Events for Weeks 13–17:

Week Number	Weekday and Date		Topics	Readings and Resources for Each Topic
13	M	4/8	**HW4 DUE ONLINE BY 11:59 PM: Practice with IRT/IFA**	
	T	4/9	Lecture 7, continued Example 7a: Multiple-Group Measurement Invariance in CFA using Mplus	
	R	4/11	Lecture 7, continued Example 7b: Longitudinal Measurement Invariance in CFA using Mplus	Edwards & Wirth (2009) Curran et al. (2014)
14	M	4/15	**OPTIONAL REVISION TO HW3 DUE VIA ICON BY 11:59 PM**	
	T	4/16	Lecture 7, continued Example 7c: Multiple-Group Measurement Invariance in IFA using Mplus WLSMV Example 7d: Multiple-Group Measurement Invariance in IFA using Mplus ML	
	R	4/18	Lecture 8: Higher-Order and Method Factor Models Example 8: Higher-Order CFA and IRT Models in Mplus	Brown (2015) ch. 8 Henninger & Meiser (2020 both) Chen et al. (2006) Reise et al. (2023)
15	M	4/22	**HW5 DUE VIA ICON BY 11:59 PM: IRT/IFA on Your Own Data**	
	T	4/23	Lecture 8 and Example 8, continued	Bandalos (2021) Tay & Jebb (2018)
	R	4/25	Lecture 8 and Example 8, continued	Davidson et al. (2016) Zhang et al. (2022)
16	M	4/29	**FA5 DUE VIA ICON BY 11:59 PM**	
	T	4/30	Discussion of FA5; Lecture 9: Structural Equation Modeling and Alternatives Example 9: Structural Equation Modeling in Mplus and R	Cole & Preacher (2014) Gonzalez et al. (2023) Curran et al. (2018)
	R	5/2	Lecture 9 and Example 9, continued	Sterba & Rights (2023) Yeng & Hancock (2023)
17	M	5/6	Office hours from 3:00-4:30 PM	
	T	5/7	NO CLASS, but office hours from 12:30-3:30 PM	
	W	5/8	Office hours from 3:00-4:30 PM	
	R	5/9	NO CLASS, but office hours from 12:30-3:30 PM	
	F	5/10	**HW6 DUE BY 5:00 PM ONLINE: (Practice with Invariance)** **OPTIONAL REVISION TO HW5 DUE VIA ICON BY 5:00 PM** **ALL OUTSTANDING WORK MUST BE COMPLETED BY 5:00 PM**	